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(54) Title: MULTI-DRUM MANUFACTURING SYSTEM FOR NONWOVEN MATERIALS

(57) Abstract: A method of manufacturing a multi-layered web uses contoured honeycomb drums for the manufacture of nonwoven webs used to make the multi-layered web. The method can use spunbonded, melt blown, or electro-static spun techniques for depositing solidifying filaments on outer collection surfaces of a multi-drum system. The multi-drum system may be employed to improve multi-layered web uniformity and the overall quality of the multi-layered web by presenting a single optimal collection surface for each independent web layer being produced.

MULTI-DRUM MANUFACTURING SYSTEM FOR NONWOVEN MATERIALS

Related Applications

This application is related to and claims priority to U.S. Patent Application Serial No. 60/212,562 entitled "Multi-Drum Manufacturing System for Nonwoven Materials," filed on June 20, 2000, and U.S. Patent Application Serial No. 60/286,802 entitled "Method and Apparatus for Bonding a Non-Woven Web," filed on April 25, 2001; and is related to U.S. Patent Application Serial No 09/733,147 entitled "Method and Apparatus for Controlling Flow in a Drum" filed on December 8, 2000, which in turn claims priority to U.S. Patent Application Serial No. 60/170,037 entitled "Method and Apparatus for Controlling Flow in a Drum, filed on December 10, 1999; International Patent Application No. PCT/US99/27294 entitled "Method and Apparatus for Manufacturing Non-Woven Articles," filed on November 17, 1999, which in turn claims priority to U.S. Patent Application Serial No. 09/193,582, filed November 17, 1998, now U.S. Patent No. 6,146,580 and U.S. Provisional Patent Application Serial No. 60/149,270, filed August 17, 1999, all the disclosures of which are incorporated herein by reference in their entirety.

Field of the Invention

This invention relates to a method of using non-woven fiber sources to produce a multi-layered web, and more particularly, forming the multi-layered web from non-woven webs, where each web is formed independently on a separate drum.

Background of the Invention

Non-woven materials are used in applications that require articles to be air permeable. Some applications of non-woven articles are surgical masks and filter membranes. Since many applications that use non-woven material entail disposable articles, the non-woven articles should be easily manufacturable and low cost. Some methods of manufacturing non-woven materials are spunbonded and melt blown processes, and electro-spinning of nano-fibers.

FIG. 1 illustrates the spunbonded process 10 for manufacturing non-woven materials. Thermoplastic fiber forming polymer 12 is placed in an extruder 14 and passed through a linear or circular spinneret 16. The extruded liquid polymer streams 18 are rapidly cooled and

attenuated by air and/or mechanical drafting rollers 20 to form desired diameter solidifying filaments 22. The solidifying filaments 22 are then laid down on a first conveyor belt 24 to form a web 26. The web 26 is then bonded by rollers 28 to form a spunbonded web 30. The spunbonded web 30 is then transferred by a second conveyer belt 32 and then to a windup 34. The spunbonded process is an integrated one step process which begins with a polymer resin and ends with a finished fabric.

FIG. 2 illustrates the melt blown process 40 for manufacturing non-woven materials. Thermoplastic forming polymer 42 is placed in an extruder 44 and is then passed through a linear die 46 containing about twenty to forty small orifices 48 per inch of die width. Convergent streams of hot air 50 rapidly attenuate the extruded liquid polymer streams 52 to form solidifying filaments 54. The solidifying filaments 54 subsequently get blown by high velocity air 56 onto a take-up screen 58, thus forming a melt blown web 60. The web is then transferred to a windup 62. U.S. Patent Number 4,380,570 entitled "Apparatus and Process for Melt-Blowing a Fiberforming Thermoplastic Polymer and Product Produced Thereby" describes the melt blown process and is incorporated herein by reference in its entirety.

While non-woven materials can be manufactured by either the spunbonded or melt blown process, there are difficulties associated with each process. For example, the newly manufactured non-woven material (e.g. melt blown web 60) tends to stick to the take-up screen 58. Further, the processes produce sheet material. Accordingly, to manufacture non-woven materials into three-dimensional shapes, e.g. surgical masks and pleated filters, some form of post-processing is required.

In addition, non-woven processes for the production of spunbond and meltblown materials may use travelling belt collectors or drums upon which to form the non-woven materials or "webs." Normally, a single drum or belt is used for this purpose. There has been some progress in the design of "multi-beam" equipment, where a traveling belt is used as a collector, and multiple spinnerettes are positioned over the belt in order to produce multi-layered webs of spunbond and meltblown materials.

The spinnerettes can be shifted to a variety of positions in order to produce composite webs of different structure, such as a layered spunbond/meltblown/spunbond (SMS) web. These layered webs can then be bonded or otherwise treated in a "post laydown" period to consolidate the layers.

Certain advantages can be achieved by use of this system. For example, one continuous belt acts as a transport system as well as a laydown area or collector for the meltblown or

spunbond fibers. There are a number of disadvantages, however. For example, each layer must be collected on top of the last deposited layer of the web. Therefore, each time a layer of the web is collected on the belt, it blocks or changes the "air flow profile" on the collector, so as to present a less desirable collecting surface for the next layer of the web. Each subsequent layer of the web therefore is generally less uniform and of poorer overall quality.

Summary of the Invention

The present invention employs at least two drums, where each drum is made of a generally tubular honeycomb member having an outer collection surface for forming a non-woven web thereon. A non-woven fiber source applies solidifying filaments to each drum. A web transport system is provided for forming a multi-layered web.

In another embodiment of the present invention, a through-air bonding apparatus may be placed in proximity to at least one of the drums to add structural integrity to the non-woven web being formed on the drum.

In yet another embodiment of the present invention, one of the drums may have a contoured outer collection surface to form a contoured non-woven web. Optionally, filler material can be added in the contours to be incorporated into the multi-layered web.

Another embodiment of the present invention relates to a method of producing a multi-layer web. In one embodiment, the method includes providing at least two drums, each drum having a generally tubular honeycomb member with an outer collection surface for forming a non-woven web thereon. A non-woven fiber source applies solidifying filaments to each drum. A web transport system is provided for forming the multi-layered web. The method includes supplying non-woven fibers from the non-woven fiber sources to the corresponding drums, forming independently non-woven webs on each of outer collection surface of the drums, and forming the multi-layer web on the web transport system.

Brief Description of the Drawings

The above and further advantages of this invention may be better understood by referring to the following description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic of a spunbonded process for manufacturing non-woven materials;

FIG. 2 is a schematic of a melt blown process for manufacturing non-woven materials;

FIG. 3A is a perspective view of an embodiment of the drum of the current invention, illustrating a contoured honeycomb tube with an outer microporous surface;

FIG. 3B is a partially exploded side view of the drum illustrating a mounting structure, vacuum apparatus, and V-belt drive groove;

FIG. 3C is a partially exploded perspective view of the drum structure;

FIG. 4 is a partial cross-sectional view of the drum taken along line 4-4 in Fig. 3A illustrating a pleated surface of the drum;

FIG. 5 is a partial radial view of the drum illustrating the honeycomb mesh;

FIG. 6 is a cross-sectional view of the drum taken along line 6-6 in Fig. 3A illustrating a contoured outer surface having a three dimensional surface;

FIG. 7 is a schematic of a process of the current invention for the manufacture of non-woven materials that substantially match the contoured outer surface of the drum;

FIG. 8 is a schematic of a process of the current invention for the post processing of non-woven materials after a three dimensional contour has been formed;

FIG. 9 is a schematic perspective view illustrating a first material and a second material bridging a three dimensional contour;

FIGS. 10A-10C are schematic perspective views illustrating three embodiments of three dimensional shapes that can be formed in a non-woven material by a process of the current invention;

FIG. 11 is a schematic perspective view of a drum apparatus for the manufacture of non-woven materials;

FIG. 12 is a schematic perspective view of an outer drum sector and an inner vacuum tube assembly or manifold of the current invention;

FIG. 13 is a schematic perspective view of an inner tube and a vacuum shell of the manifold of the current invention;

FIG. 14 is a schematic top view of a vacuum frame of the inner tube and vacuum shell depicted in FIG. 13;

FIG. 15 is a partial cross-sectional view of the vacuum tube assembly taken along line 15-15 in FIG. 14;

FIG. 16 is a cross-sectional view of the inner tube and vacuum shell taken along line 16-16 in FIG. 15;

FIG. 17 is an exploded view of Detail 17 in FIG. 15;

FIG. 18 is a schematic bottom view of an inner tube of the manifold;

FIG. 19 is a schematic side view of the inner tube of the manifold;

FIG. 20 is a partial cross-sectional view of the inner tube taken along line 20-20 in FIG.

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FIG. 21 is a schematic perspective view of vanes for controlling air flow direction in the manifold;

FIG. 22 is a schematic side view of the shell and inner tube showing the orientation of the vanes for controlling air flow direction in the manifold;

FIG. 23 is a schematic perspective view of one set of vanes installed in the manifold;

FIG. 24 is a schematic exploded view of the inner tube, the vacuum shell, the vanes, the frame, the brackets, and the honeycomb of the manifold;

FIG. 25 is a perspective view of a drum and a through-air bonding apparatus for the manufacture of non-woven materials;

FIG. 26 is a front view of a drum and bonding manifold of the current invention;

FIG. 27 is a side view of a drum and through-air bonding system of current invention;

FIG. 28 is a side view of a portion of the drum surface and manifold of the current invention;

FIG. 29 is a side view of a portion of a contoured drum surface and manifold of the current invention;

FIG. 30 is a table showing typical ranges of process parameters for the current invention;

FIG. 31 is a schematic diagram illustrating an apparatus for forming a multi-layered web; and

FIG. 32 is a schematic diagram illustrating another apparatus for forming a multi-layered web.

Detailed Description of the Invention

Referring to FIG. 3A, shown is a drum 100 having a contoured outer surface 102 which may take many different shapes and forms. As shown, the drum 100 is made of a tubular honeycomb member 104 that is surrounded by a microporous layer 106. The microporous layer 106 is tack welded to the tubular honeycomb member 104 and may be finely electroetched stainless steel having numerous holes on the order of about 0.010 inches (0.25 mm) in diameter, at a spacing such that the microporous layer 106 is uniformly about fifty percent open. A frame 108 rotatably supports the drum 100. The material for the tubular honeycomb member 104 can be, but is not limited to, stainless steel.

Referring to FIG. 3B, the drum 100 is supported by the frame 108 or frames, so that the drum 100 can be rotated as the solidifying filaments are continuously applied by spunbonded or

melt blown processes or by electro-spinning of nano-fibers. FIG. 3B also shows an internal pipe 70 with a vacuum port 72 and a bearing surface 74. The pipe 70 is located in the center of the drum 100. The pipe 70 also has a slot 73 that is in communication with the vacuum port 72 to draw a negative pressure 75 through a sector of the drum 100 to conform the solidifying filaments to the contour. See FIG. 7. Also shown is V-belt drive 76 which can be used to rotate the drum 100 by any conventional source known to those skilled in the art, such as a variable speed motor.

Referring to FIG. 3C, the drum 100 includes inner support bars 78 which are located throughout the drum 100. The inner support bars 78 provide stiffness to the drum 100 and allow a negative pressure 75 or positive pressure 79 to be provided to a portion of the drum 100, as shown in FIG. 7. FIG. 3C also shows that the drum 100 includes a plurality of panels 80 that can attached to the drum 100 by a variety of means (e.g., fasteners or clips). The panels 80 can be made of honeycomb with a microporous outer layer to form any desired contoured outer surface 102.

Referring to FIG. 4, shown is a partial cross-sectional view of one embodiment of the drum 100 of the present invention. The drum 100 has a contoured outer surface 102 that has the shape of alternating peaks 110 and valleys 112. The contoured outer surface 102 is covered by the microporous layer 106. As will be further shown, the contoured outer surface 102 with alternating peaks 110 and valleys 112 can be used to form pleated-shaped non-woven articles useful as particulate air filters.

Referring to FIG. 5, shown is a partial radial view of a portion of the drum 100 illustrating a rectangular mesh 114 of tubular honeycomb member 104. The mesh 114 consists of alternating multiple rows of mesh holes 116, where each row is offset from the previous row. Each mesh hole has a length 118 and width 120. In one embodiment the mesh hole length 118 is about 0.5 inches (1.3 cm) and the width 120 is about 0.25 inches (0.64 cm). By using a rectangular mesh 114, the honeycomb member 104 can be readily formed into a circular contour.

Referring to FIG. 6, shown is another partial cross-sectional view of the drum 100 illustrating a three dimensional form 122 that is attached (e.g., tack-welded) to the drum 100. The three-dimensional form 122 also has honeycomb construction and can be formed by, but not limited to, electrical discharge machining. The three-dimensional form 122 is also covered by the microporous layer 106. As will be further shown, the three-dimensional form 122 can be used to make, for example, a surgical mask shaped article.

FIG. 7 shows one process for manufacturing contoured non-woven articles. Thermoplastic forming polymer 150 is placed in an extruder 152 and passed through a linear die 154 containing about twenty to forty or more small orifices 156 per inch of die 154 width. Convergent streams of hot air 158 rapidly attenuate the extruded liquid polymer 160 to form solidifying filaments 162. The solidifying filaments 162 subsequently get blown by high velocity air 163 onto the contoured outer surface 102 of drum 100. Note that the method illustrated in FIG. 7 for generating the solidifying filaments 162 is a melt blown process, but a spunbonded process, or any other method for generating the solidifying filaments 162 can be used, such as electro-spinning of nano-fibers using an electrostatic spun technique. Melt blown process equipment is available from Biax Fiberfilm Corporation located in Wisconsin.

The drum 100, which is rotating, has a contoured outer surface 102, which can have a combination of shapes, for example, alternating peaks 110 and valleys 112 or a series of three dimensional forms 122. Once the solidifying filaments 162 are deposited on the drum 100, a vacuum or negative pressure 75 can be applied to a portion of the drum 100 to conform the solidifying filaments 162 to the contoured outer surface 102, to prepare closely matching contoured non-woven materials 164.

After the contoured non-woven materials 164 are formed, the rotating drum 100 rotates to a point where the contoured non-woven materials 164 are removed from the drum 100. Positive pressure 79 can optionally be applied through a portion of the drum 100 to facilitate removing the contoured non-woven materials 164 from the drum 100. Once off the drum 100, the contoured non-woven material 164 can be post processed in a variety of post processing operations, for example by application of a spray 165. The treatment can consist of adding various supplements such as flame retardents, stain repellents, colored dyes, and the like, or to change the shape, feel, texture, or appearance of the contoured non-woven material 164.

FIG. 8 is an expanded view of additional optional post processing performed on the contoured non-woven material 164. In addition to the treatment operations discussed above, a first material 171 may be added to the contoured non-woven material 164 in order to achieve desired properties in a final product 168. The first material 171 may be a non-woven material or any other material, based on properties required in the final product 168. For example, some materials that can be used for the first material 171 are absorbent substances or charcoal or other filter materials known to those skilled in the art. The first material 171 may be selected based on desired material properties such as pore size, fiber diameter and length, basis weight, and density.

FIG. 8 shows a process step 180 for adding the first material 171 to the contoured non-woven material 164. The process 180 for adding the first material 171 to the contoured non-woven material 164 may be a spunbonded process or a melt blown process for non-woven materials. Alternatively, loose fill or pre-formed sheet goods, with or without an adhesive treatment, can be deposited on the non-woven material 164. If the first material 171 is a material other than a non-woven material, a person skilled in the art can choose the appropriate method for manufacturing the desired material. An additional process 172 can add a second different material 173 on top of the first material 171. The same considerations used to select the first material 171 can be used to select the second material 173.

A covering material 182 from a source 181 may be placed over the contoured non-woven material 164. The covering material 182 captures or retains the first material 171 and the optional second material 173 within the contoured non-woven material 164. Some materials that may be used for the covering material 182 are organic fibers, inorganic fibers, and polymers, which can be in the form of woven or non-woven sheet goods, films, and the like, and which may or may not be porous. The covering material 182 may be adhered or bonded to the contoured non-woven material 164 by a variety of processes 184 known to those skilled in the art, such as a pair of rollers, a heated die, etc. to seal and/or laminate the layers. Additional layers of materials and coverings may be applied, as desired.

FIG. 9 illustrates the presence of the first material 171 and the second material 173 in the valleys of a pleated contoured non-woven material 164. The first material 171 and the second material 173 effectively bridge 174 the peaks 110 in the pleated material 164. The bridge 174 may be made up of just the first material 171, a combination of the first material 171 and the second material 173, or a plurality of different desired materials. The bridge 174 may bridge or partially or fully fill any three dimensional contour.

The process of FIG. 8 results in a wide variety of articles which can be used in a variety of applications. One embodiment resulting from the process of FIG. 8 consists of a non-woven material 164, where the first material 171 added is a carbon filtration material and a covering material is applied overall. Another embodiment consists of a non-woven material 164, where the material added results in a varying ~~gradient filter article~~. The varying gradient filter article has multiple filter layers. Each layer can have its own filter pore size. Each layer in the varying gradient filter article can trap different particle sizes. In addition, another embodiment of the process of FIG. 8 consists of a non-woven material 164, where the first material 171 added can be a high loft material, so that the resultant article can be used for absorption of oil or other

liquid. Other materials can be selected by a person skilled in the art, based on the particular application and performance sought.

FIGS. 10A-10C show additional three dimensional contours which can be manufactured by the process, such as half tube 175, multinodal 176, and pyramidal or frustoconical 177 contours. Other contours, both regular and irregular, will be apparent to those skilled in the art based on the teachings herein.

Referring back to FIG. 7, after any post processing has been completed, the contoured non-woven material 164 may pass through a cutter 166, to cut the contoured non-woven material 164 into the desired article or final product 168. The cutter 166 may be a die, water jet, laser, or any other apparatus capable of trimming to the desired contour. Any waste 170 after the cutting operation can either be disposed of or recycled. Accordingly, non-woven contoured articles such as wipes, filters, face masks, sorbent products, insulation, clothing, and the like can be rapidly produced from polypropylene, polyester, or other materials in a continuous process at low cost.

While an open, apertured inner tube 70, such as that depicted in FIG. 3B, may be used in a variety of applications with good results, it may be desirable to better control the pressure and/or flow across the drum 100 by using an internal manifold with adjustable features and low losses. Accordingly, the amount of suction or pressure applied to the material deposited on the drum can be tailored for the particular material, density, contour, etc.

Referring to FIG. 11, shown is an embodiment of an apparatus 130 for the manufacture of non-woven articles. The apparatus 130 includes a rotatable honeycomb drum 100. The drum 100 can have a contoured surface, as discussed hereinabove, and have an adjustable manifold disposed therein.

Referring to FIG. 12, shown is an embodiment of a manifold tube assembly 200 for controlling flow in the drum 100, solely a portion of which is depicted. The tube assembly 200 includes an inner tube 202 and a vacuum shell 206. Either vacuum or pressure may be applied to the drum 100. The tube assembly 200 defines an air flow path inside the drum 100. The air flow path passes through a honeycomb panel 216, past a partition top 208, along a channel formed between the inner tube 202 and the vacuum shell 206, through port 215, and inner tube 202. See FIG. 16. Air may flow into or out of the manifold 200 and the drum 100 along the flow path defined above, depending on whether vacuum or pressure is applied to the inner tube 202.

Referring to FIG. 13, shown is a perspective view of an embodiment of the inner tube 202 and vacuum shell 206 of the manifold 200. The inner tube 202 passes through the vacuum shell 206. The vacuum shell 206 has a partitioned bottom 203 to direct air through a plurality of

ports 215 of inner tube 202 to allow air to pass into or out of the inner tube 202. See FIG. 18. The vacuum shell 216 includes a vacuum plate 205 at each end sealed to the inner tube 202 to prevent air from leaking around the inner tube 202. A honeycomb panel 216 can be mounted within vacuum frame 211, as shown in FIG. 24, to provide a uniform distribution of air flow through the vacuum shell 206.

FIG. 13 shows the vacuum shell 206 is split into left and right halves by a center ring partition 201 and along its longitudinal axis by top partition 208 and bottom partition 203. FIG. 15 shows each side or half can be balanced for airflow via a plurality of gate valves 210, which can be adjusted independently to uncover, partially cover, or fully cover the ports 215. The double tube arrangement (inner tube 202 within vacuum shell 206) is used to provide tailored airflow without the use of a plurality of separate pipes. The double tube configuration of the manifold 200 also provides an efficient method for redirecting airflow from a radial to an axial direction.

FIG. 14 shows a view of the inner tube 202 and vacuum shell 206 viewed through the vacuum frame 211. This view illustrates the center ring 201 for dividing the air flow at a midpoint of the inner tube 202 and the drum 100. Two additional rings 201', 201" are depicted, which further subdivide the vacuum frame opening into eighths.

Referring to FIG. 15, shown is a partial cross-sectional view of the inner tube taken along line 15-15 in FIG. 14. FIG. 15 illustrates one embodiment for controlling the flow of air in the drum. Gates 210 can be moved over ports 215 to modify the flow of air into or out of inner tube 202. In one embodiment, the gates 210 are slotted and can be attached to the inner tube 202 by screws 213.

Referring to FIG. 16, shown is a partial cross-sectional view of the inner tube 202 and vacuum shell 206 along line 16-16 in FIG. 15. FIG. 16 illustrates the flow path of air drawn through the drum 100 and into the manifold 200. For descriptive purposes only, a vacuum flow through the drum is described, but the path can be reversed to apply a pressure to the drum to facilitate removing a non-woven article formed thereon. Air is drawn through the outer drum honeycomb assembly (not shown), through the honeycomb panel 216, into an annular channel formed between the vacuum shell 206 and the inner tube 202, and then into the inner tube 202 through ports 215. FIG. 16 also shows once the air is in the inner tube 202, air is drawn out of the inner tube through one or more openings at the ends of the inner tube 202.

FIG. 17 is an exploded view of Detail 17 in FIG. 15 to illustrate the relationship between the ports 215, gates 210, and screws 213. As may be readily understood, by subdividing the

vacuum tube assembly into a plurality of zones, with airflow paths independently controllable using the gates 210, vacuum or pressure applied to various zones of the drum passing thereover can be tailored to achieve a desired result.

FIG. 18 is a bottom view of the inner tube 202 showing the ports 215 in the inner tube 202 which allow air to pass into or out of the inner tube 202. This embodiment employs sixteen ports 215. FIG. 19 is a side view of inner tube 202.

Referring to FIG. 20, shown is a view along cross-section 20-20 of the inner tube 202 of FIG. 19. Tapped holes for the gate screws 213 may be located for convenient access to facilitate adjustment of the gates 210. In this embodiment, they may be located at an angle α of about 100° to about 110°, although any location can be selected.

Referring back to FIG. 13, the vacuum shell 206 is split into left and right halves by a center ring portion 201 and along its longitudinal axis by top partition 208 and bottom partition 203. FIG. 13 shows an embodiment where the vacuum shell 206 is divided by similar rings 201', 201" which are parallel to the outer ring, further subdividing the shell 206 into multiple compartments. In this embodiment, there are eight compartments so formed. Each compartment can be balanced for airflow volume via a separate gate valve 210 which can be adjusted to uncover, partially cover, or fully cover two ports 215. In addition, the efficiency of airflow in each compartment can be enhanced and losses reduced by using optional flow turning vanes 217.

FIG. 21 shows a perspective view of the flow turning vanes 217 used in each compartment. Rails 227 are connected to leading edges of the flow turning vanes 217 to hold the flow turning vanes 217 together. The flow turning vanes 217 are then placed on the top partition 208 as best seen in FIG. 23. Once the flow turning vanes are placed on the top partition 208, the downstream edges of the flow turning vanes 227 are suspended in the annular channel between the inner tube 202 and the vacuum shell 206. By altering the distance between the downstream edges the airflow speed may be altered over the entire surface covered by the vanes 217.

FIG. 22 is a side view of the inner tube 202 and the vacuum shell 206 which shows the position of the flow turning vanes 217 in the annular channel between the inner tube 202 and the vacuum shell 206. FIG. 22 also shows the relationship between the manifold 200 and the drum 100. Note that only a section of the drum 100 is shown in FIG. 22.

FIG. 23 is a perspective view of two sets of the vanes 217 installed in two of the compartments of the manifold 200 and FIG. 24 is an exploded view. Vanes 217 can be used in all, some, or none of the compartments and can be of similar or different number and configuration, depending on the particular application and desired results. In the assembly, the

flow turning vanes 217 and rails 227 are placed on the top partition 208. Then the frame 211 is mounted to the vacuum shell 206. Brackets 218 are then screwed on to the vacuum shell 206 to constrain the frame 211. Screws 222 to attach the frame 211 to the vacuum shell 206 run through holes 220 in the brackets 218. Finally, an optional honeycomb panel 216 is placed inside the frame 211. The height of the honeycomb 216 relative to the turning vanes 217 can be adjusted.

The double arrangement of the inner tube 202 within the vacuum shell 206, coupled with the flow turning vanes 217 and gate valves 210, are used to provide tailored air flow on the honeycomb panel 216 and, accordingly, through the drum 100, in both machine direction and cross direction. The double arrangement of the inner tube 202 within the vacuum shell 206, coupled with the turning vanes 217, also provides a method for redirecting airflow from a radial to an axial direction efficiently.

The following detailed description relates to a method and apparatus for use with a honeycomb drum and a through-air bonding apparatus for forming non-woven articles. The method and apparatus provide a hot air flow through non-woven articles being formed on the drum which bonds the non-woven articles internally, without the use of compression rollers or heated calender rollers.

Referring to FIG. 25, shown is an embodiment of an apparatus 600 for the manufacture of non-woven articles. The apparatus 600 includes a rotatable honeycomb drum 502. The drum 502 can have a contoured outer surface, as discussed above. In addition, the apparatus 600 also includes a through-air bonding apparatus 504.

The apparatus 600 includes a drum control unit 506 to control the movement of the drum 502 and a hot air control unit 508 to control the temperature, pressure, and volume of air to be used to internally bond and consolidate non-woven articles formed on the drum 502. Air is supplied from an air source to the hot air control unit 508 and then conveyed to the through-air bonding system 504 through one or more pipes 510. In one embodiment, unheated air can be supplied to the through-air bonding apparatus 504. The air can be heated by one or more heaters 512 attached to the through-air bonding apparatus 504. Heated air is then fed to a manifold 514 in the through-air bonding apparatus 504.

Referring to FIG. 26, shown is an embodiment of the drum 502 and manifold 514 of the through-air bonding apparatus 504. The air is fed from pipes 510 to heaters 512 to heat the air. Heated air is fed by pipes 516 to the manifold 514. The manifold 514 generally include a flow control honeycomb structure 518 to provide a uniform distribution of the heated air to the

drum 502. The manifold 514 also includes a centrally located internal manifold compartment bulkhead 519 and optionally can include further bulkheads, turning vanes, etc. to provide a more uniform or tailored distribution of heated air. The controlled distribution of heated air results in predetermined consolidation of non-woven materials formed on the drum 502. Using a tailored distribution of heated air to achieve predetermined consolidation of non-woven materials can be important in forming non-woven materials with three-dimensional shapes. Heated air exits the manifold 514 through manifold aperture 520. As disclosed in the above-referenced patents, a vacuum can be drawn through the drum 502. The heated air exiting the aperture 520 can be drawn through the non-woven material and the drum 502 and out through the center of the drum through air duct 522.

Referring back to FIG. 25, the air duct 522 is used to return the air back to the air source. The apparatus of FIG. 25 also includes an aperture height adjustment 524 to adjust the height or standoff of the aperture 520 relative to the drum 502.

FIG. 27 shows one embodiment of the drum 502 and through-air bonding apparatus 504 which uses a spun bond method for creating a non-woven web; however, melt blown, electro spinning of nano-fibers, or other methods of making a non-woven webs known to those skilled in the art can be used.

A spinneret 526 generates a series of solidifying filaments or fibers 528 which form a non-woven web 530 on drum 502. Note that a belt can be used in place of the drum 502. The drum 502 then moves the non-woven web 530 past a separation panel 532 and passes the non-woven web 530 under the through-air bonding apparatus 504. The separation panel 532 isolates the newly formed non-woven web 530 from hot air until the non-woven web 530 is positioned under the through-air bonding apparatus 504.

Prior to applying hot air, the non-woven fibers 528 from the spunbound process which form the non-woven web 530 and can easily be pulled apart. At this point the non-woven web 530 does not have enough structural integrity to be passed from the drum 502 to a web transfer roll 536. A through-air bonding process applies hot air from the through-air bonding apparatus 504 to the non-woven web 530 to achieve an internally bonded, consolidated non-woven material 534.

After the hot air passes through the non-woven material 530, the hot air is drawn into the drum 502 through a vacuum or hot air collection system 538 in the drum 502. The hot air then passes to air ducts 522 which return the air back to the air source.

The amount of bonding provided to the non-woven material can be adjusted by changing the temperature of the air, the distance of the aperture 520 supplying the air relative to the drum 502, the velocity of the air, and the volume of air. The amount of bonding can be set to achieve a desired material property in the non-woven material. Some material properties that can be affected by the amount of bonding are the softness and drape of the non-woven material. The drape of the non-woven material is the ability of a non-woven material to fold onto itself and conform to the shape of an article it covers.

In addition, the amount of bonding applied to the non-woven material 530 can be set to provide enough structural integrity to eliminate the need for compression rollers and heated calender rollers used in the prior art to provide structural integrity to the non-woven web 530. By eliminating the use of compression rollers and heated calender rollers, the resulting internally bonded non-woven material 534 has more loft than if the heated calender rolls and compression rollers were used. However, if one desires to have certain non-woven material properties associated with the use of calender rolls, such as strength or compaction, a calender roll may be added downstream from the through-air bonding apparatus 504.

After passing under the through-air bonding apparatus 504, the bonded non-woven material 534 is transferred to a web transfer roll 536. Then the bonded non-woven material 534 can be post-processed as discussed above.

Referring to FIG. 28, shown is an embodiment of the manifold 514 and drum 502. FIG. 28 shows dimension D, which represents the height of the aperture 520 in the manifold 514 relative to the drum 502. The height D can be adjusted by the height adjustment mechanism 524 shown in FIG. 25, using twin screws. By adjusting the height D, the amount of bonding of the non-woven material 530 can be modified to achieve a desire material property in the bonded non-woven material 534.

FIG. 29 illustrates an embodiment of the drum 502 and the through-air bonding apparatus 504 where the drum 502 has three-dimensional contours. The three-dimensional contours on the drum 502 allow a non-woven article with a three-dimensional shape to be formed using the methods described above. By using through-air bonding, this allows bonded non-woven materials 534 with three-dimensional shapes to be bonded without the use of compression rollers or heated calender rolls. Bonding non-woven materials with three-dimensional shapes without the use of compression rollers or heated calender rolls allows the non-woven material to maintain its three-dimensional shape.

FIG. 30 is a table showing typical ranges of process parameters in accordance with the

current invention.

A multi-drum system may be employed to improve multi-layered web uniformity and the overall quality of the non-woven product by presenting a single optimal collection surface for each independent web layer being produced. In FIG. 31, a first drum 702 is shown collecting solidifying fibers 704 from a spunbond spinneret 706. A vacuum port 708 on the drum 702 may be "air flow balanced" as previously described and, by design, presents an optimum condition to the fibers for formation of the spunbond layer of the web 710. Each subsequent drum similarly provides an optimum condition for producing one or more additional spunbond and/or meltblown layers. FIG. 31 also shows drum 712 collecting solidifying fibers 714 from spunbond spinneret 716 to form a second spunbond layer 718. Spunbond layers 710 and 718 may be passed through respective nip rollers 719. In addition, also shown in FIG. 31 is drum 720 collecting solidifying fibers 722 from a melt blown source 724 to form meltblown layer 726. Each web layer is then independently distributed to the transport system 728 for incorporation and consolidation into the multi-layered web 730. In one embodiment, the transport system 728 can be a travelling belt. The multi-layered web 730 can be calendared with calendar rolls 732, if desired.

Optionally, other roll goods may be distributed into the multi-layered web 730, such as a thin polymer film 734, shown in FIG. 31. Similarly, other optional processes may be incorporated "in line," such as bonding or finishing, shown as post processing apparatus 735. In the embodiment shown in FIG. 31, the multi-layer web 730 is made from spunbond layers 710 and 718, meltblown layer 726, and film layer 734.

Through-air bonding of the web can be advantageously employed on one or more of the drums in order to provide bonding, strength, and integrity to the various layers of the web. As previously described, heated air 736 is applied, through a manifold 738, over a wide area of the web, in order to cause a softening and/or slight melting of the individual fibers. The fibers are fused together at the points where they touch or contact each other, causing a permanent bond joint. If desired, the fibers may be specially manufactured to improve the bonding conditions. This may include the use of bi-component fibers, such as a polypropylene material core sheathed with polyester material, or a "side-by-side" configuration of polypropylene and polyester fibers. This technique takes advantage of the lower melting point of the second component fiber, enhancing the bond condition.

Multi-zone thru-air ovens may be used for highloft bonding of the web at low speeds. Heated air is applied to the spunbond layer of the web, as it is newly formed on the surface of a

drum. The spunbond layer is thereby provided with enough structural integrity to be unwound from the drum, for post processing, or for introduction of the spunbond layer into a multi-layered web structure. In this manner, the web can be processed at very high speeds utilizing through-air bonding on a drum collector. For a description of thermal bonding methods, refer to web page entitled "Thermal bonding processes," found at address http://www.nonwovens.com/facts/technology/bonding/thermal.htm, the disclosure of which is incorporated herein in its entirety by reference.

In the "stacked drum" configuration shown in FIG. 32, other processes are shown being accommodated. In this embodiment, a meltblown process is combined with a spunbond process and a 3-D meltblown process, in accordance with the description hereinabove. The meltblown process uses meltblown fiber source 740 to provide meltblown fibers 742 to form a meltblown web 744 on drum 746. The spunbond process uses spunbond fiber source 748 to provide spunbond fibers 750 to form spunbond web 752 on drum 754. Manifold 755 can be used to supply heated air 757 to cause a softening or slight melting of the fibers. The 3-D meltblown process uses meltblown fiber source 756 to provide meltblown fibers 758 to form contoured meltblown web 760 on contoured drum 762. Further, an optional dispenser 764 distributes materials 766 such as cellulose, carbon, filtration, superabsorbent, or other materials into the 3-D shapes to produce a filled layered web. Superabsorbent materials are also known as superabsorbent particles or SAP. Superabsorbent materials are disclosed in U.S. Patent No. 5,064,653, the contents of which are incorporated by reference in its entirety. Typical superabsorbent materials include sodium and aluminum salts of starch grafted copolymers of acrylates and acrylamides and combinations thereof, as well as polyacrylate salts. A film layer, impervious to the flow of liquids therethrough, may optionally be added, as desired. Subsequent finishing operations may include bonding with bonding rolls 768 or other treatment of the web to further consolidate or process the multi-layered material.

Many different combinations and permutations of the configurations of the embodiments described above are possible. For example, multiple sources of non-woven fibers could be applied to either different circumferential or axial locations on a drum. In addition, a belt may be used in place of a drum.

Variations, modifications, and other implementations of what is described herein will occur to those of ordinary skill in the art without departing from the spirit and the scope of the invention as claimed. Accordingly, the invention is to be defined not by the preceding illustrative description, but instead by the following claims.

CLAIMS

1. An apparatus for forming a multi-layered web, the apparatus comprising:

two drums, each drum comprising a generally tubular honeycomb member having an outer collection surface for forming a non-woven web thereon;

a non-woven fiber source corresponding to each drum; and

a web transport system for forming the multi-layered web from the non-woven webs formed on the drums.

2. The invention according to claim 1 wherein at least one the drums further comprises a microporous layer covering at least a portion of the outer collection surface thereof.

3. The invention according to claim 1 wherein the non-woven fiber sources are selected from the group consisting of a spun-bonding source, an electro spinning nano-fibers source, and a melt blown source.

4. The invention according to claim 1 wherein the apparatus further comprises a through-air bonding apparatus in proximity to at least one of the drums.

5. The invention according to claim 1 wherein the apparatus further comprises a post processing device in proximity to the web transport system.

6. The invention according to claim 1 wherein the apparatus further comprises a film source for providing a film with the multi-layer web.

7. The apparatus of claim 1 wherein at least one of the drums comprises a contoured outer collection surface for forming a contoured non-woven web.

8. The apparatus of claim 7 further comprising a dispenser located proximate the contoured outer collection surface for providing a filler material to the contoured non-woven web.

9. The apparatus of claim 8 wherein the dispenser dispenses filler material selected from the group consisting of cellulose material, carbon material, filtration material, and superabsorbent material.

10. The invention according to claim 1 wherein at least one of the drums further comprises a flow control device for tailoring flow through the outer collection surface thereof.

11. The invention according to claim 1 wherein the apparatus further comprises calender rolls for calendering the multi-layer web.

12. A method for producing a multi-layer web, the method comprising the steps of:

providing an apparatus comprising:

two drums, each drum comprising a generally tubular honeycomb member having an outer collection surface for forming a non-woven web thereon;

a non-woven fiber source corresponding to each drum; and

a web transport system for forming the multi-layered web from the non-woven webs formed on the drums.

supplying non-woven fibers from the non-woven fiber sources to the corresponding drums;

forming independently non-woven webs on each outer collection surface of the drums; and

forming the multi-layer web on the web transport system.

13. The method according to claim 12 wherein at least one the drums further comprises a microporous layer covering at least a portion of the outer collection surface thereof.

14. The method according to claim 12 wherein the non-woven fiber sources are selected from the group consisting of a spun-bonding source, an electro spinning nano-fibers source, and a melt blown source.

15. The method according to claim 12 wherein the apparatus further comprises a through-air bonding apparatus in proximity to at least one of the drums.

16. The method according to claim 15 further comprising the step of providing structural integrity to at least one of the non-woven webs using the through-air bonding apparatus.

17. The method according to claim 12 wherein the apparatus further comprises a post processing device in proximity to the web transport system.

18. The method according to claim 17 further comprising the step of post-processing at least one non-woven web.

19. The method according to claim 12 wherein the apparatus further comprises a film source for providing a film with the multi-layer web.

20. The method of claim 19 further comprising the step of adding a film to the multi-layer web.

21. The method according to claim 12 wherein at least one of the drums comprises a contoured outer collection surface for forming a contoured non-woven web.

22. The method according to claim 21 wherein the apparatus further comprises a dispenser located proximate the contoured outer collection surface for providing a filler material to the

contoured non-woven web.

23. The method according to claim 22 further comprising the step of adding a filler material to at least one contour in the contoured non-woven web.

24. The method according to claim 22 wherein the dispenser dispenses filler material selected from the group consisting of cellulose material, carbon material, filtration material, and superabsorbent material.

25. The method according to claim 12 wherein at least one of the drums further comprises a flow control device for tailoring flow through the outer collection surface thereof.

26. The method according to claim 25 further comprising the step of tailoring flow through at least one of the drums.

27. The method according to claim 12 wherein the apparatus further comprises calender rolls for calendering the multi-layer web.

28. The method according to claim 27 further comprising the step of calandering the multi-layer web.

29. A multi-layer web produced in accordance with the method of claim 12.

30. A multi-layer web comprising:

a first spun bond non-woven web;

a melt blown non-woven web disposed thereon; and

a second spun bond non-woven web disposed on the melt blown non-woven web.

31. The multi-layer web according to claim 30 further comprising a film.

32. The multi-layer web according to claim 31 wherein the film is disposed between the first spun bond non-woven web and the melt blown non-woven web.

33. A multi-layer web comprising:

a first melt blown non-woven web;

a second melt blown non-woven web disposed thereon; and

a spun bond non-woven web disposed on the second melt blown non-woven web.

34. The multi-layer web according to claim 33 further comprising filler material.

35. The multi-layer web according to claim 34 wherein the filler material is disposed between the first melt blown non-woven web and the second melt blown non-woven web.

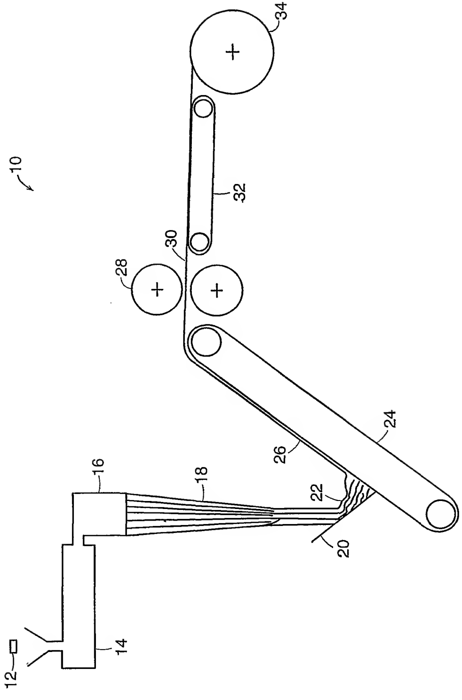

FIG. 1
PRIOR ART

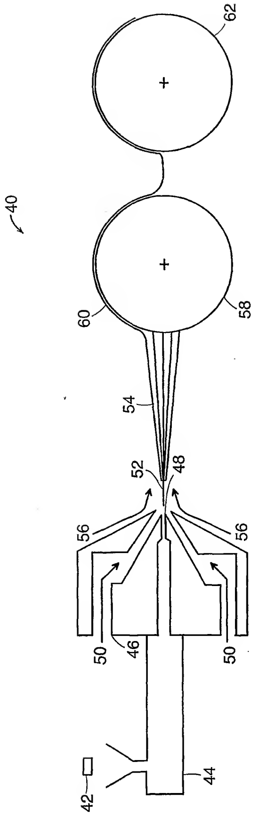

FIG. 2
PRIOR ART

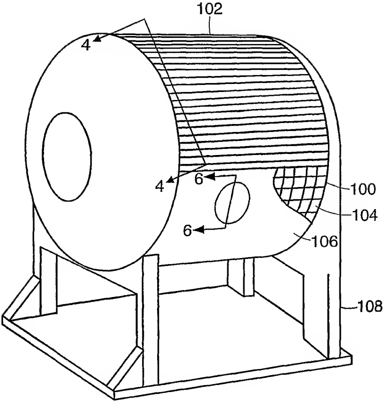

FIG. 3A

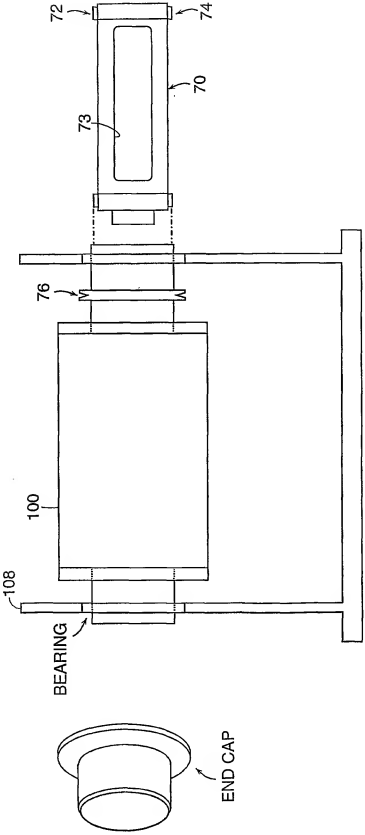

FIG. 3B

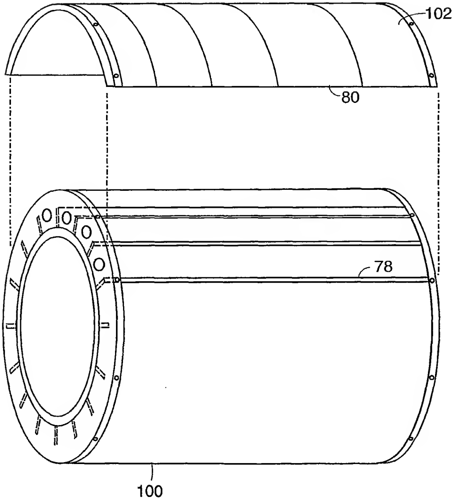

FIG. 3C

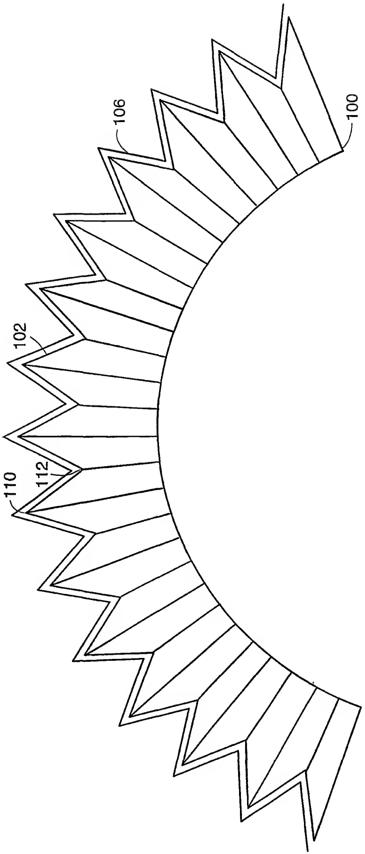

FIG. 4

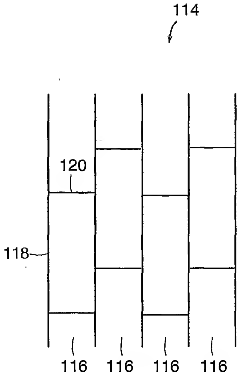

FIG. 5

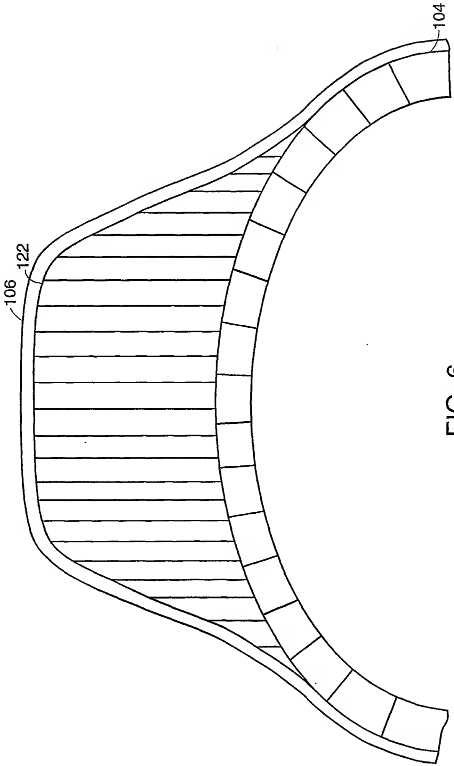

FIG. 6

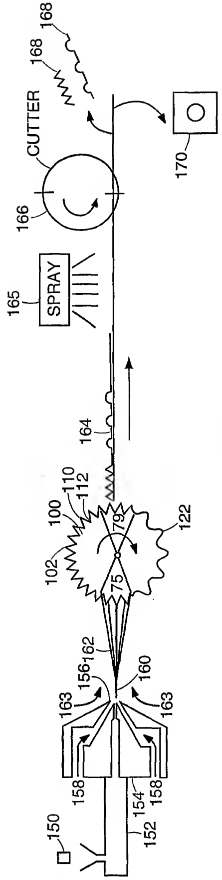
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FIG. 7

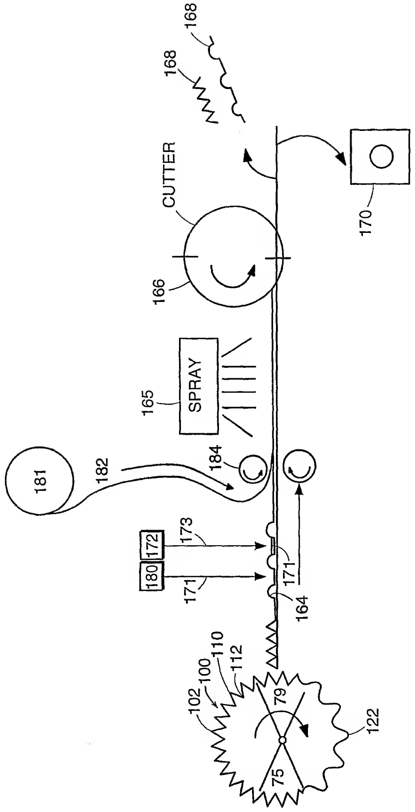
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FIG. 8

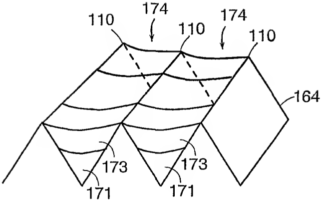

FIG. 9

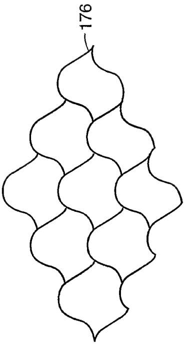

FIG. 10B

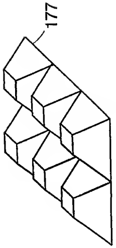

FIG. 10C

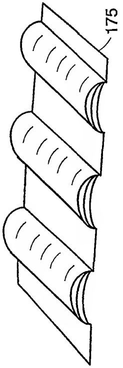

FIG. 10A

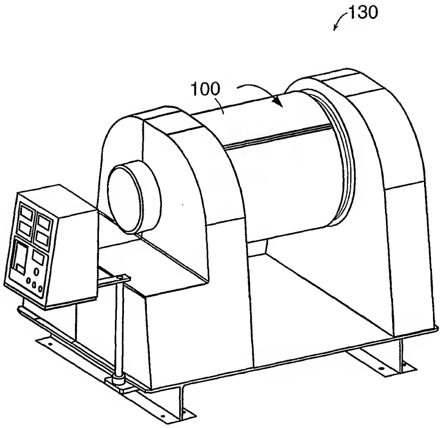

FIG. 11

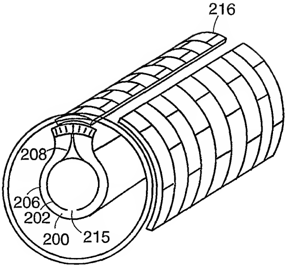

FIG. 12

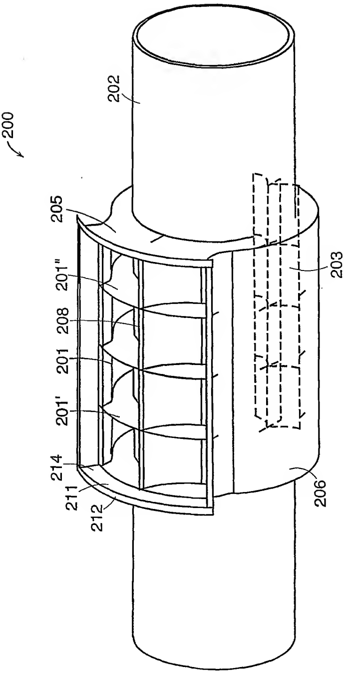

FIG. 13

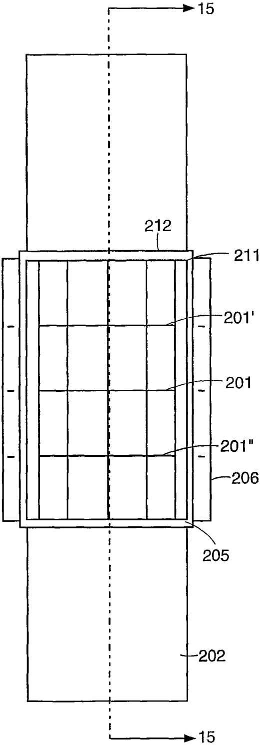

FIG. 14

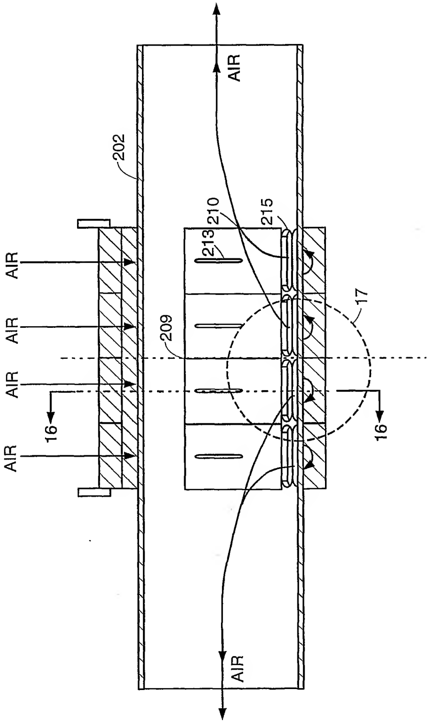

FIG. 15

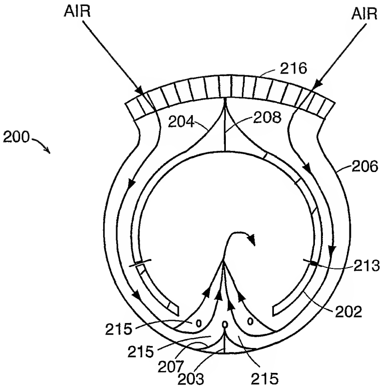

FIG. 16

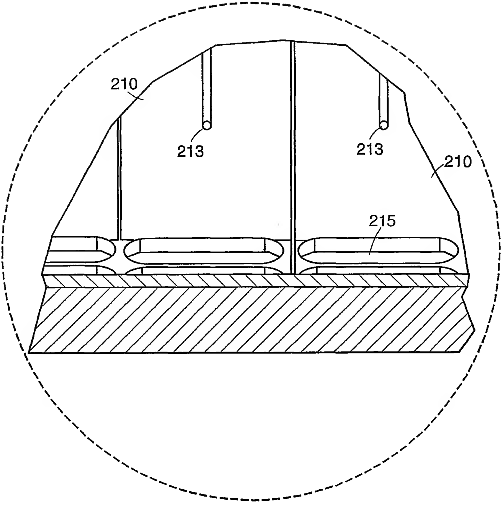

FIG. 17

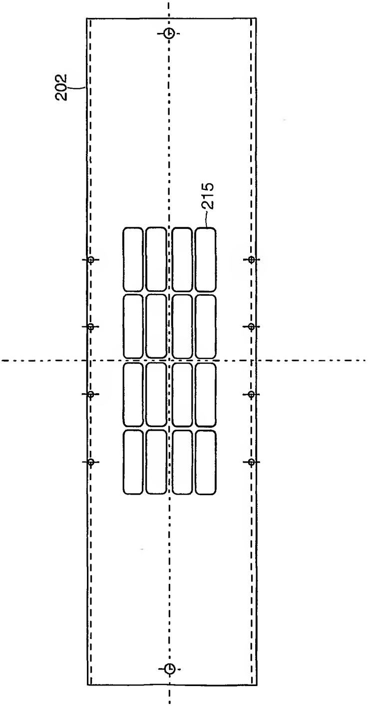

FIG. 18

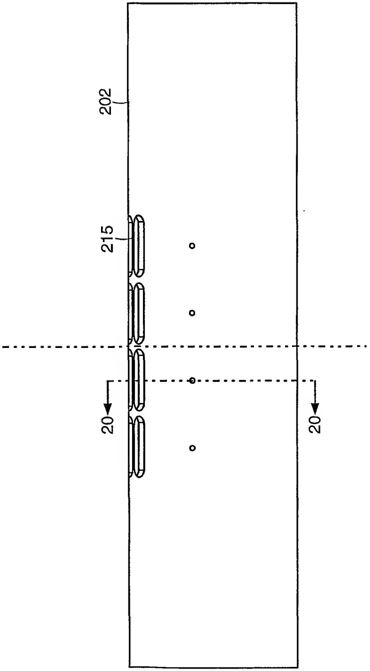

FIG. 19

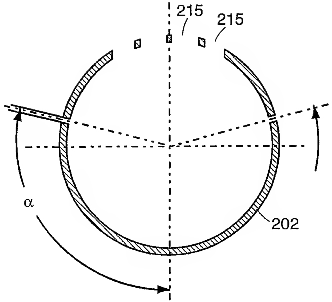

FIG. 20

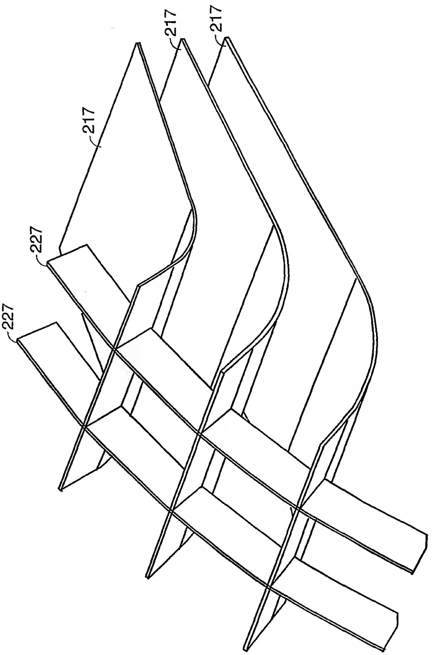

FIG. 21

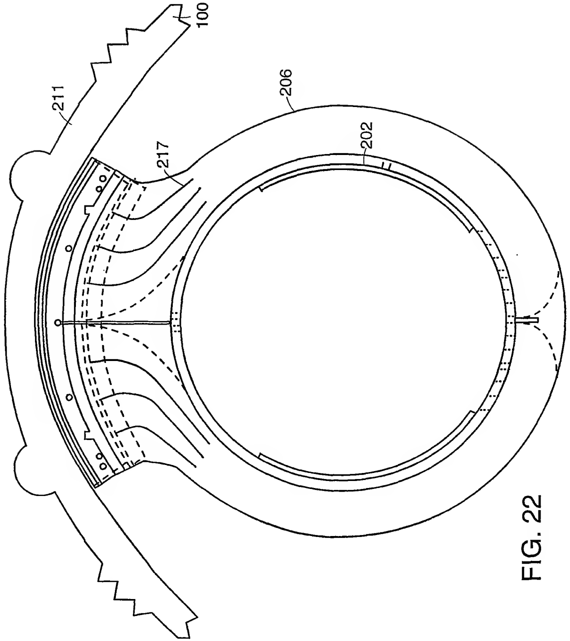

FIG. 22

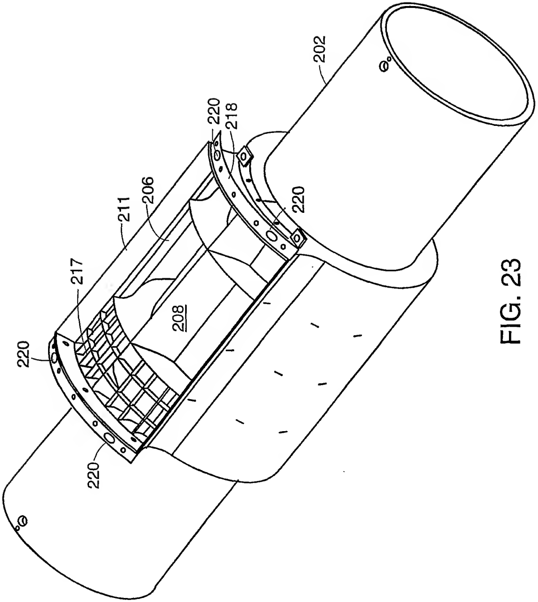

FIG. 23

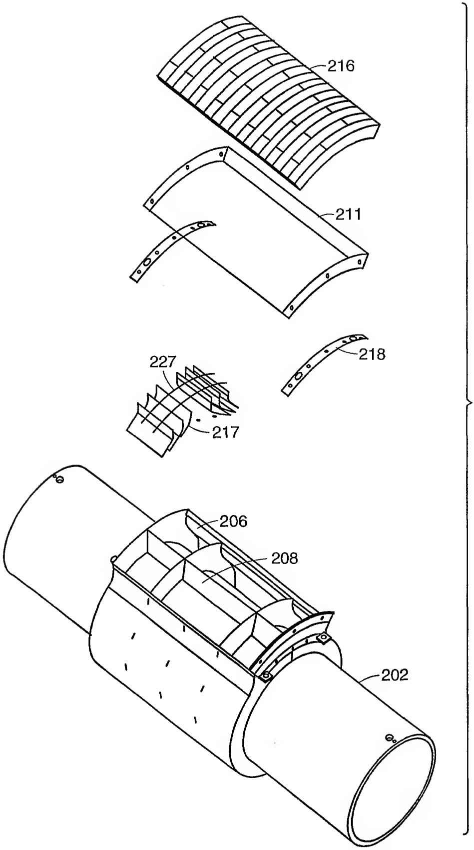

FIG. 24

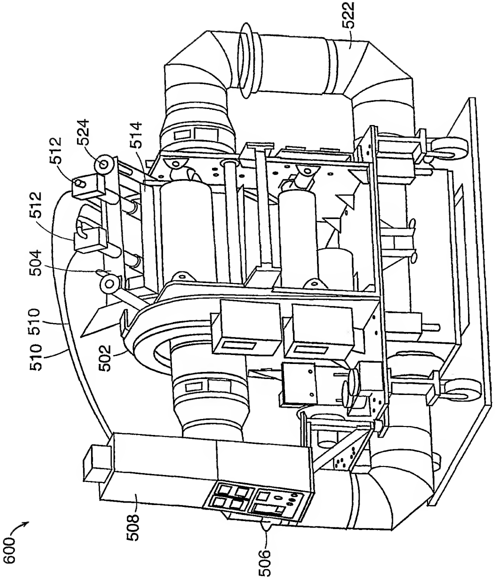

FIG. 25

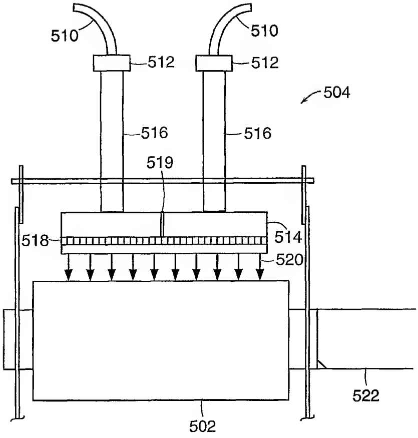

FIG. 26

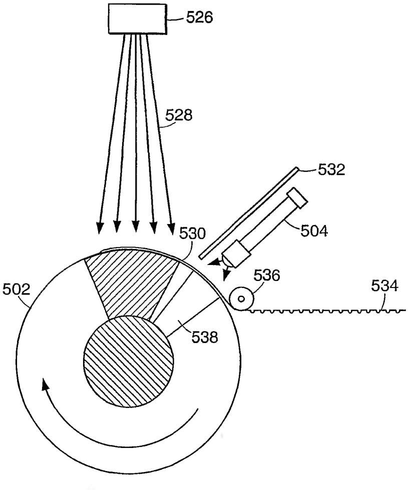

FIG. 27

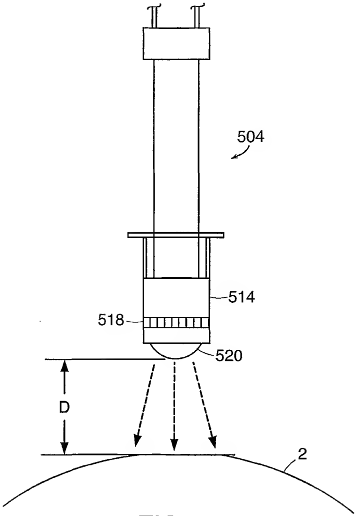

FIG. 28

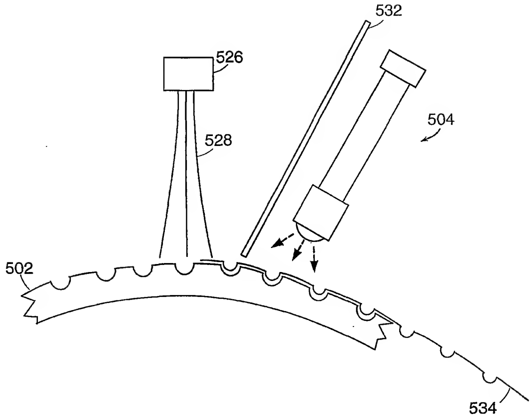

FIG. 29

THROUGH-AIR BONDING PROCESS PARAMETERS

*	TOTAL AIR VOLUME (CROSS DIR)	=	ABOUT 2 CFM OR HIGHER/FOOT WIDTH
*	AIR SPEED THRU THE APERTURE	=	LESS THAN ABOUT 1,000 FT/MIN
*	AIR SPEED THRU THE WEB	=	LESS THAN ABOUT 800 FT/MIN
*	AIR TEMPERATURE IN MANIFOLD	=	ABOUT 200 TO 600°F
*	AIR TEMPERATURE ON WEB SURFACE	=	ABOUT 100 TO 500°F
*	DWELL TIME ON WEB	=	ABOUT 0.01 TO 1.0 SEC
*	MANIFOLD PRESSURE	=	LESS THAN ABOUT 2" H_20
*	COLLECTOR SURFACE SPEED	=	ABOUT 10 FT/MIN OR HIGHER
*	DISTANCE-APERTURE TO WEB (ADJUSTABLE)	=	LESS THAN ABOUT 0.5 INCH TO ABOUT 6 INCHES
*	AIR FLOW UNIFORMITY AT APERTURE	=	LESS THAN ABOUT ±5%
*	AIR FLOW UNIFORMITY AT DRUM HOT AIR COLLECTOR FIG. 3, 38	=	LESS THAN ABOUT ±5%
*	TEMPERATURE UNIFORMITY AT APERTURE	=	LESS THAN ABOUT ±5%
*	HOT AIR VELOCITY AT THE WEB	=	WITHING ABOUT ±200 FT/MIN OF HOT AIR COLLECTION AIR SPEED

FIG. 30

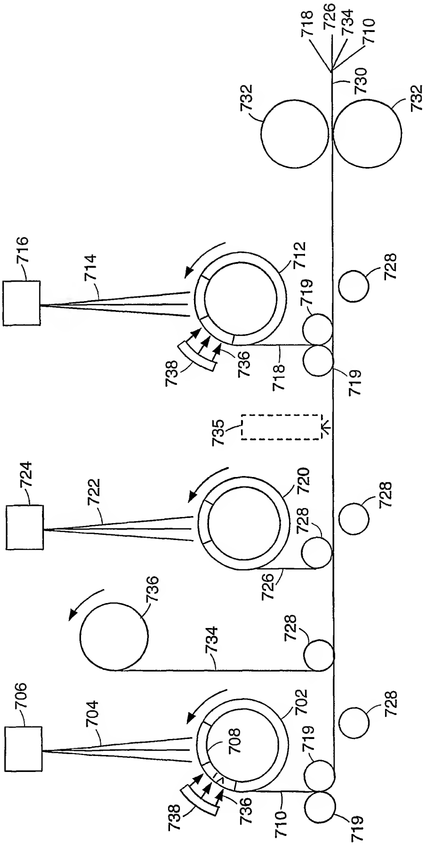

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FIG. 31

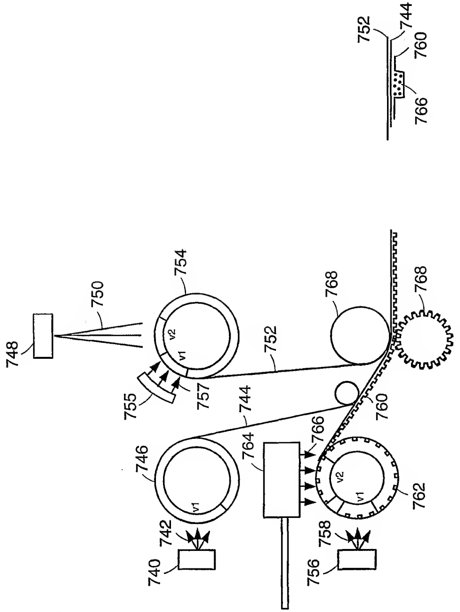
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FIG. 32

D 2

Abstract of **EP0404982**

In the continuous production of non-woven mineral wool, fibre/gas/air mixtures (3, 4) generated by a plurality of unravelling units (14 to 17) are directed, to form a wool lap (25), onto collecting conveyor units (19, 21) having curved suction surfaces (c, d) which are under suction pressure. The arrangement is such that each fibre/gas/air mixture formed by the individual unravelling units (14 to 17) is assigned an imaginary suction surface increasing in size in the conveying direction, specifically d c. It is thereby possible, in a space-saving design, with a constant suction pressure to produce on each collecting conveyor unit mineral-wool laps of rock wool with bulk densities even below 25 kg/m<3> of good product quality. Furthermore, multi-layered felt webs can be formed by connecting a plurality of units in series or by an oscillating deposition of an individual lap.

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(54) Verfahren und Einrichtung zur Herstellung von Mineralwollevliesen aus insbesondere Steinwolle.

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Beschreibung

Die Erfindung betrifft ein Verfahren und eine Einrichtung zur kontinuierlichen Herstellung von Mineralwollevliesen aus insbesondere Steinwolle nach den Oberbegriffen der Ansprüche 1 und 2 sowie Verfahren zur kontinuierlichen Herstellung von aus mehreren Mineralwollevliesen zusammengesetzten Filzbahnen nach den Ansprüchen 17 oder 18.

Bei der Herstellung von Mineralwollevliesen z. B. aus Stein- oder Glaswolle ist neben der Zerfaserung selbst die Bildung des Vlieses als solches ein wichtiger Verfahrensschritt. Bekanntlich wird hierbei ein durch eine Zerfaserungseinheit erzeugtes Faser-/Gas-/Luft-Gemisch zur Abtrennung der Fasern in einen kastenartigen sogenannten Fallschacht eingeführt, welcher meist bodenseitig einen als eine Art Filterband wirkenden Sammelförderer aufweist, der in der Regel in der Form eines gasdurchlässigen umlaufenden ebenen Transportbandes ausgebildet ist. Unter dem Transportband befindet sich dabei eine Absaugvorrichtung, die einen bestimmten Unterdruck erzeugt.

Trifft nun das Faser-/Gas-/Luft-Gemisch - welches auch ein Bindemittel enthalten kann - auf den Sammelförderer auf, so wird das Gas-/Luft-Gemisch unterhalb des als Filter wirkenden Sammelförderers abgesaugt, und die Fasern legen sich auf diesem als Vlies ab. Verwendet man dagegen einen Fallschacht mit mehreren hintereinander angeordneten Zerfaserungseinheiten, um Mineralwollevliese zu erhalten, die im Vergleich zu der erstgenannten Einrichtung höhere Wolleauflagen, d. h. höhere Flächengewichte besitzen, so stellt das bereits gebildete Teilvlies der jeweils vorherigen Zerfaserungseinheit einen zusätzlichen Strömungswiderstand in Verbindung mit dem jeweils nachfolgenden Teilvlies für die Absaugung des Gas-/Luft-Gemisches dar. Dies bedeutet, je mehr Zerfaserungseinheiten in einem Fallschacht zusammenarbeiten, um so höher wird der Strömungswiderstand in Förderrichtung des Gesamtvlieses, und damit steigt der Energieverbrauch der Absaugvorrichtung, mit dessen Saugdruck der jeweilige Strömungswiderstand überwunden werden muß. Zur Veranschaulichung dieses Prinzipes wird beispielsweise auf die US-PS 3 220 812 verwiesen.

Neben dem erhöhten Energieverbrauch hat eine derartige Gesamtvliesbildung den entscheidenden Nachteil, daß durch die hierbei entstehenden relativ hohen Differenzdrücke zwischen Absaugvorrichtung und Vliesoberfläche das sich bildende Mineralwollevlies derart zusammengedrückt werden kann, daß dieses den Fallschacht vorverdichtet verläßt. Dies hat zur Folge, daß dadurch vorgegebene Mindestraumgewichte des Gesamtmineralwollevlieses nicht unterschritten werden können, d. h., Raumgewichte bei Wollevliesen z. B. aus Steinwolle unter 25 kg/m³ sind mit derartigen Einrichtungen kaum herstellbar.

Hinzu kommt noch, daß die Vliesbildung vielfach nicht homogen verläuft, so daß unterschiedliche Flächengewichte verteilt über die Gesamtfläche des Vlieses entstehen können. Ferner besteht bei derartigen Einrichtungen mit einer Mehrzahl von Zerfaserungseinheiten der Nachteil, daß bei der Forderung, ein Mineralwollevlies mit relativ hohem Flächengewicht herzustellen, eventuell einige Zerfaserungseinheiten abgeschaltet werden müssen, sobald die Kapazität der Absaugvorrichtung, d. h. deren Ventilatorenleistung überschritten wird, um den Fallschacht funktionsfähig zu halten.

Der Umstand, daß die Vliesdicke zum Auslauf des Fallschachtes hin zunimmt und die Durchströmungsgeschwindigkeit bei konstantem Saugdruck zum Auslauf des Fallschachtes hin abnimmt, hat bei herkömmlichen Fallschächten auch dazu geführt, daß die Absaugbereiche unter dem Transportband in mehrere Zonen unterteilt wurden, und zwar mit in Förderrichtung zunehmendem Saugdruck. Das Problem der hohen Differenzdrücke und somit das unerwünschte Vorverdichten des Gesamtvlieses wurde jedoch mit dieser Maßnahme nicht gelöst.

Hier will die vorliegende Erfindung Abhilfe schaffen. Ihr liegt die Aufgabe zugrunde, ein Verfahren und eine Einrichtung vorzuschlagen, womit es möglich ist, Mineralwollevliese, vorzugsweise aus Steinwolle, mit Rohdichten auch unter 25 kg/m³ in guter Produktqualität kontinuierlich herzustellen, und womit auch eine Verringerung des Energieaufwandes für die Absaugung erzielt wird; ferner Verfahren anzugeben, mit denen eine kontinuierliche Herstellung von mehrschichtigen Filzbahnen aus den gebildeten Mineralwollevliesen geringer Rohdichte einwandfrei möglich ist.

Die Lösung des ersten Teiles dieser Aufgabe ergibt sich durch die kennzeichnenden Merkmale der Ansprüche 1 und 2. Dadurch wird erreicht, daß mit zunehmender sich bildender Vliesdicke die zur Verfügung stehende Absaugfläche in ihrer Größe zunimmt. Dies gilt insbesondere bei einer gekrümmten Fläche, da hier die Abwicklungslänge größer ist als die Waagrechte ihrer senkrechten Projektion. Letzterer Umstand bedeutet ferner, daß beim Einsatz von mehreren Zerfaserungseinheiten, diese im gleichen Abstand zueinander platzsparend angeordnet werden können, und dennoch pro Einheit jeweils die zur Verfügung stehenden Absaugflächen in Förderrichtung zunehmen. Hierbei gilt ganz allgemein die Funktion: Absaugfläche $A = f(\zeta)$, wobei ζ den Widerstandsbeiwert des jeweiligen Mineralwollevlieses darstellt und hauptsächlich von dessen Flächengewicht und Faserfeinheit abhängig ist.

Die Grundbedingung für einen Druckverlust bei einer Strömung ist hierbei folgende:

$$\Delta p = \zeta \frac{\rho}{2} w^2,$$

wobei ρ = Dichte des Gas-/Luft-Gemisches (kg/m^3) und w = Strömungsgeschwindigkeit (m/s) bedeutet.

Nimmt man nun an, daß sowohl der Volumenstrom jeder Zerfaserungseinheit als auch Δ p der Absaugvorrichtung konstant sind, so ergeben sich die Beziehungen:

$$w_1 \times A_1 = w_2 \times A_2$$
$$\zeta_1 \times \frac{\rho}{2} \times w_1^2 = \zeta_2 \times \frac{\rho}{2} \times w_2^2$$
$$w_2 = w_1.$$

Hieraus folgt wiederum, daß sich in Förderrichtung die Strömungsgeschwindigkeit proportional zur Wurzel des Verhältnisses der Widerstandsbeiwerte verringert, oder um den Volumenstrom konstant zu halten, gilt:

$$A_2 = A_1 \cdot \sqrt{\frac{\zeta_2}{\zeta_1}}$$

Daraus folgt ferner, daß die zur Verfügung stehenden Absaugflächen zwar auch eben ausgebildet werden könnten, was aber bei konstantem Saugdruck in Förderrichtung zunehmende Abstände der Zerfaserungseinheiten bedeuten würde und somit mehr Platzbedarf. Dieser erkannte Zusammenhang stellt jedoch - die Neuheit vorausgesetzt - eine Erfindung für sich dar.

Die in diesem Zusammenhang gebrauchte Definition "fiktive Absaugfläche" soll so verstanden sein, daß die einzelnen Absaugzonen nicht wie im Stand der Technik konstruktiv durch Querwände unterteilt sind. Vielmehr stellen sich diese aufgrund der lotrechten Projektion der z. B. keilförmigen Geometrie der beim Düsenblasverfahren pro Zerfaserungseinheit sich bildenden ebenen Freistrahlbündel ein, wobei sich hierbei die Grenzen der einzelnen Absaugzonen infolge der Turbulenz in einem Fallschacht überschneiden können. Wesentlich ist hierbei jedoch, daß für jede Freistrahlprojektionsfläche in Förderrichtung eine sich vergrößernde Absaugfläche zur Verfügung steht, wodurch es einerseits vorteilhaft möglich ist, den Saugdruck in der Sammelfördereinheit konstant zu halten und insgesamt mit einer geringeren Absaugleistung zu arbeiten. Letztere Maßnahmen ermöglichen wiederum eine geringere Wolleauflage pro Flächeneinheit und somit die Herstellung von Mineralwollevliesen mit relativ geringen Rohdichten.

In diesem Zusammenhang ist zwar aus der DE-OS 21 22 039 eine Einrichtung zur Herstellung eines Wollevlieses bekannt, bei der die von einer Zerfaserungseinheit kommenden Fasern auch auf einer gekrümmt verlaufenden Absaugfläche auftreffen, und zwar in Form einer sich mit hoher Geschwindigkeit (45 m/sec.) drehenden Saugtrommel, jedoch erfolgt hier die eigentliche Vliesbildung nicht auf der Saugtrommel, da diese eine zu hohe Umfangsgeschwindigkeit besitzt, sondern in einem nachgeschalteten trichterförmigen sogenannten Verteiler, der die gleiche Breite wie die Saugtrommel hat. Da derartige auch im Bereich des Düsenblasverfahrens eingesetzte bekannte Saugtrommeln eine Umfangsgeschwindigkeit besitzen sollen, die mehr oder weniger der Geschwindigkeit der erzeugten Fasern entspricht, dienen diese nicht zur Ablage des eigentlichen Faservlieses, sondern nur zum Absaugen des Gas-/Luft-Gemisches. In dieser DE-OS 21 22 039 ist ferner auch ein Fallschacht mit mehreren Zerfaserungseinheiten und zwei zueinander gegenläufig sich drehenden Saugtrommeln aufgezeigt. Hierbei ist jedoch lediglich an hintereinander angeordnete Zerfaserungseinheiten gedacht, deren Mittellinien in einer lotrechten Ebene liegen, zu der wiederum symmetrisch die zwei Saugtrommeln angeordnet sind, wobei diese nach dem gleichen Prinzip arbeiten wie die anfänglich beschriebene einzelne Saugtrommel.

Wenn bei der erfindungsgemäßen Einrichtung nur eine gasdurchlässige Sammelfördereinheit mit mindestens einem gekrümmt verlaufenden Bereich und hierzu im Abstand zu diesem Bereich ein in bezug auf den Fallschacht abdichtendes Leitelement verwendet wird, so ist dieses gemäß Anspruch 3 bevorzugt mit seiner dem gekrümmt verlaufenden Bereich gegenüberliegenden Fläche in Förderrichtung bewegbar ausgebildet. Damit wird erreicht, daß das sich bildende Wollevlies besser ausgetragen wird.

Ein derartiges abdichtendes Leitelement ist auf jeden Fall erforderlich, um einen nicht bestimmungsgemäßen Austritt von Luft und Fasern aus dem Fallschacht zu verhindern. Letzteres gilt auch für den Austragsspalt des Wollevlieses, denn hier muß die Abdichtung durch das Wollevlies selbst erfolgen. Die abdichtende Wirkung des Vlieses wird jedoch von seinem Raumgewicht, seiner Rückfederungskraft und der Zusammenhangskraft des Vlieses selbst bestimmt, so daß z. B. ein Vlies mit langen elastischen Einzelfasern besser in der Lage ist, einen Austragsspalt auszufüllen als bei gleicher Spaltbreite ein Vlies mit kürzeren Einzelfasern. Andererseits kann der Austragsspalt nicht beliebig eng gewählt werden, da sonst für höhere Flächengewichte eine zu große Vorverdichtung entstehen würde. Es kann deshalb gemäß Anspruch 4 zweckmäßig sein, daß der lichte Abstand zwischen

dem Leitelement und der Sammelfördereinheit einstellbar ausgebildet wird.

Gemäß Anspruch 5 kann es auch vorteilhaft sein, daß anstelle des Leitelementes eine weitere Sammelfördereinheit vorgesehen wird, welche dann die Frage der Abdichtung gegenüber dem Fallschacht auf der Seite des ursprünglich vorgesehenen Leitelementes übernimmt. Bei einer derartigen Anordnung von zwei Sammelfördereinheiten kommt die erfinderische Idee dann voll zum Tragen, wenn gemäß Anspruch 6 dieser Doppeleinheit mindestens drei Zerfaserungseinheiten zugeordnet sind, und zwar symmetrisch mit der dritten Zerfaserungseinheit in der Mitte zwischen der Doppeleinheit. Auch in diesem Falle kann es gemäß Anspruch 7 zweckdienlich sein, daß der zwischen den Sammelfördereinheiten zum Austragen des Vlieses vorgesehene Spalt in seiner Breite veränderbar ist.

Muß der Austragsspalt zwischen den Sammelfördereinheiten z. B. aus verfahrenstechnischen oder konstruktiven Gründen konstant gehalten werden, so wird nach Anspruch 8 vorteilhaft vorgeschlagen, diesen konstanten Spalt durch mindestens ein in Förderrichtung nachgeschaltetes verstellbares Element in seiner Breite zu variieren, wobei gemäß Anspruch 9 dieses verstellbare Element vorteilhaft eine antreibbare Walze oder ein antreibbares Förderband sein kann. Auch können hierfür gemäß Anspruch 10 zwei antreibbare, in einem veränderbaren Abstand zueinander angeordnete Walzen oder Förderbänder zur Anwendung kommen.

Diese einstellbaren in Förderrichtung nachgeschalteten Elemente haben insofern große Bedeutung, als es mit einer erfindungsgemäßen Einrichtung möglich sein muß, Mineralwollevliese mit den unterschiedlichsten Flächengewichten herzustellen. Entsprechend den Erfahrungen bei herkömmlichen Fallschächten mit mehreren Zerfaserungseinheiten, und hier insbesondere mit solchen, die nach dem Düsenblasverfahren arbeiten, hat sich gezeigt, daß Wollevliese mit Raumgewichten im Bereich des Austrages aus dem Fallschacht kaum unter ca. 25 kg/m^3 und, um Vorverdichtung zu vermeiden, kaum über 75 kg/m^3 liegen können, da sonst keine brauchbare und störungsfreie Fertigung mehr möglich ist. Dies entspricht einer Auflagenvariation von ca. 1 : 3, gewünscht ist jedoch eine Variationsspanne von 1 : 12 und mehr. Besondere Anforderungen stellt dabei das Austragen von Vliesen mit relativ geringen Auflagen, da hier der innere Zusammenhalt des Vlieses am geringsten ist. Solche Vliese können daher bei einem nicht bestimmungsgemäßen Luftaustritt durch den Austragsspalt mit ausgeblasen werden, oder sie lösen sich bei einem zu großen Saugdruck kaum von dem Sammelförderer ab. Ferner ist zu beachten, daß bei einem eventuellen Ausfall einer Einheit der hier vorgesehenen vier Zerfaserungseinheiten nur ein Drittel des Gesamtflächengewichtes auf die eine Sammelfördereinheit gelangt, was die Anforderungen an den Vliesaustrag ebenfalls erhöht. Zur Lösung dieser Forderungen tragen insbesondere die Merkmale der bereits genannten Ansprüche 8 bis 10 bei.

Aber auch weitere Maßnahmen helfen, diesen Forderungen Rechnung zu tragen, und zwar kann gemäß Anspruch 11 vorteilhaft vorgesehen werden, daß die zur Verfügung stehenden Absaugflächen jeder Sammelfördereinheit, insbesondere im Bereich des zum Austrag des Vlieses vorgesehenen Spaltes, in ihrer Größe einstellbar sind; ferner, daß gemäß Anspruch 12 mindestens vor einem nachgeschalteten Element eine Abblasevorrichtung vorgesehen ist, durch welche die sich bildenden Vliese manipulierbar sind.

Die erfindungsgemäße Einrichtung nach den Ansprüchen 2 bis 12 bietet vor allem den wesentlichen Vorteil, daß für die Ablageflächen der Sammelförderer relativ dünne, perforierte Bleche verwendet werden können, da sie keine hohen Flächenlasten aufnehmen müssen; d. h. ferner, daß sonst statisch notwendige Querrippen mit entsprechender Bauhöhe entfallen können, wodurch beidseitig glatte Sammelförderoberflächen erhalten werden, die sich rein mechanisch gut sauberhalten lassen. Dies kann vorteilhaft durch die Kombination mindestens einer elastischen walzenförmigen Bürste erfolgen, die von innen die Perforation eines Sammelförderers mit dessen gleicher Umfangsgeschwindigkeit durchkämmt und mindestens einer weiteren walzenförmigen Bürste, welche die äußere Oberfläche mit einer im Vergleich zum Sammelförderer wesentlich höheren Umfangsgeschwindigkeit abreinigt. Damit ist ein Trockenbetrieb der erfindungsgemäßen Einrichtung vorteilhaft möglich, welcher gegenüber dem Stand der Technik wesentliche verfahrenstechnische und kostenmäßige Vorteile mit sich bringt, da dort im allgemeinen aufwendige Naß-/Trocknungs-Reinigungseinrichtungen verwendet werden müssen, um die Perforation der Sammelförderer von eventuell anhaftenden Faser- und Bindemittelresten freizuhalten.

Die erfindungsgemäße Einrichtung eignet sich gemäß Anspruch 13 besonders zur Erzeugung von Vliesen aus Steinwolle, die nach dem Düsenblasverfahren erzeugt wird. Mit diesem Verfahren war es bisher jedoch kaum möglich, Vliese auf der Basis von Steinwolle mit Rohdichten unter 25 kg/m^3 wirtschaftlich und betriebssicher herzustellen. Das Düsenblasverfahren zeichnet sich bekanntlich dadurch aus, daß aus einem eine Mineralschmelze enthaltenden Tiegel unter der Wirkung der Schwerkraft Schmelzeströme austreten, die in einer Ziehdüse unter der Wirkung von im wesentlichen parallel zu den Schmelzeströmen strömenden Gasen hoher Strömungsgeschwindigkeit zerfa-

sert, ausgezogen und unter die Erweichungstemperatur abgekühlt werden. Gemäß Anspruch 14 kann es in diesem Zusammenhang bezüglich zunehmender Ablageflächen auch zweckmäßig sein, daß die Zerfaserungseinheiten derart geneigt angeordnet sind, daß die von diesen erzeugten Fasern unter einem von der Senkrechten abweichenden Neigungswinkel auf die Sammelfläche auftreffen.

Ferner hat es Vorteile, wenn als Sammelförderer eine rotationssymmetrische Einheit gewählt wird, d. h., daß nach Anspruch 15 mindestens eine Sammelfördereinheit als Trommel ausgebildet ist, wobei nach Anspruch 16 der Saugdruck in jeder Sammelfördereinheit für sich regelbar sein sollte, damit man sich unterschiedlichen Betriebsbedingungen leicht anpassen kann.

Die zweite Teilaufgabe der vorliegenden Erfindung wird vorteilhaft gemäß Anspruch 17 durch ein Verfahren gelöst, bei dem zur kontinuierlichen Herstellung einer aus mehreren Einzelvliesen zusammengesetzten Filzbahn die von mehreren erfindungsgemäßen Einrichtungen kommenden Einzelvliese gemeinsam auf einem laufenden Förderband zu einer Filzbahn abgelegt werden.

Alternativ dazu kann es gemäß Anspruch 18 auch vorteilhaft sein, eine zusammengesetzte Filzbahn aus einem einzigen Vlies zu bilden, in dem dieses auf einem laufenden Förderband durch eine pendelnde Bewegung auf diesem zu einer mehrschichtigen Filzbahn abgelegt wird.

Weitere Einzelheiten, Merkmale und Vorteile der Erfindung ergeben sich aus der nachfolgenden Beschreibung von Ausführungsbeispielen anhand der Zeichnung:

Es zeigt:

- Fig. 1 schematisch vereinfacht einen Schnitt durch ein erstes Ausführungsbeispiel einer erfindungsgemäßen Einrichtung zur Herstellung von Mineralwollevliesen mit zwei Zerfaserungseinheiten und einem gasdurchlässigen Sammelförderer, der im Bereich der Faserablage eine gekrümmt verlaufende Absaugfläche aufweist,
- Fig. 2 schematisch vereinfacht einen Schnitt durch ein zweites Ausführungsbeispiel einer erfindungsgemäßen Einrichtung mit vier Zerfaserungseinheiten und zwei gegenläufigen Sammelförderern in Form von Trommeln und eine nachgeschaltete verstellbare Abdichtwalze,
- Fig. 3 ein in einer der Fig. 2 im wesentlichen entsprechenden Darstellung drittes Ausführungsbeispiel mit zwei den Trommeln nachgeschalteten verstellbaren Abdichtwalzen,
- Fig. 4 eine schematisch vereinfachte Darstellung von zwei hintereinander angeordneten Einrichtungen gemäß Fig. 3, jedoch hier jeweils als viertes Ausführungsbeispiel statt den Walzen zwei in einem veränderbaren Abstand zueinander angeordnete Förderbänder, wobei die Einzelvliese gemeinsam auf einem laufenden Produktionsband zu einer zusammengesetzten Filzbahn abgelegt werden und
- Fig. 5 ein perspektivisch schematisch dargestellter Ausschnitt aus der Fertigungslinie gemäß Fig. 4, jedoch wird hier ein Einzelvlies durch eine pendelnde Bewegung seiner Führungsförderbänder auf einem laufenden Produktionsband zu einer zusammengesetzten Filzbahn abgelegt.

Wie aus Fig. 1 ersichtlich, werden durch zwei nach dem Düsenblasverfahren arbeitenden Zerfaserungseinheiten 1 und 2 in ihrer Geometrie etwa keilförmige Freistrahlbündel 3 und 4 erzeugt, die aus einem Faser-/Gas-/Luft-/Bindemittel-Gemisch bestehen, und die von einem kastenförmig ausgebildeten Fallschacht 5 umgeben sind. Den unteren Abschluß des Fallschachtes 5 bildet eine Sammelfördereinheit 6, die zwei gekrümmt verlaufende mit "a" und "b" bezeichnete Absaugflächen hat, auf die sich die von den Zerfaserungseinheiten 1, 2 kommenden Fasern zu einem Wollevlies 7 ablegen. Die Sammelfördereinheit 6 weist ein umlaufendes perforiertes Förderband 8 auf, das in Richtung des Pfeiles 9, der Förderrichtung, motorisch angetrieben wird (in der Zeichnung nicht dargestellt). Ferner ist innerhalb der Sammelfördereinheit 6 eine nicht dargestellte Absaugvorrichtung vorgesehen, deren erzeugter Saugdruck lediglich in einer unterhalb der gekrümmt verlaufenden Absaugflächen "a" und "b" angeordneten Saugkammer 11 wirksam wird. Gegenüber der gekrümmt verlaufenden Absaugfläche "b" ist in einem bestimmten Abstand von dieser ein einen sogenannten Austragsspalt 12 begrenzendes und gegenüber dem Fallschacht 5 abdichtendes Leitelement 13 in der Form eines Bleches vorgesehen, das im vorliegenden Fall ortsfest angeordnet ist.

Die keilförmige Geometrie der Faserfreistrahlbündel 3, 4 ist in Fig. 1 idealisiert dargestellt, obwohl in der bisherigen Praxis im Fallschacht bestimmte Turbulenzen auftreten. So kann es beispielsweise in herkömmlichen Fallschächten vorkommen, daß es wenige Zentimeter (ca. 2 bis 10 cm) über dem sich bildenden Vlies zu sehr starken Querströmungen kommt, die in ihrem Betrag größer als die mittlere Anströmgeschwindigkeit sind, und die zu einer Verschlechterung der Faserablage durch Rollen- und Strähnenbildung führen können. Diesen Querströmungen entsprechend müssen auch die jeweiligen statischen Drücke im Bereich

bis zu ca. 10 cm über dem sich bildenden Vlies verteilt sein. So konnten beispielsweise Drücke von ca. 40 mm/WS gegen die Atmosphäre und Querströmungen von ca. 30 m/sec. an den Enden der Absaugzone gemessen werden. Ähnliche, jedoch weitaus weniger ausgeprägte Druck- und Strömungsverhältnisse erfordern deshalb auch bei den vorliegenden Ausführungsbeispielen der erfinderischen Einrichtung, daß der Austragsspalt definiert abgedichtet ist, und zwar ist im vorliegenden Fall der Austragsspalt 12 durch das Gesamtvlies 7 abgedichtet.

Zurückkommend auf die in Fig. 1 deutlich gezeigten Absaugflächen "a" und "b" ist festzuhalten, daß die Bogenlänge der Absaugzone "b" größer ist als die der Absaugzone "a". Durch dieses erfinderische Konzept wurde vorteilhaft erreicht, daß die höhere Faserauflage im Bereich der Absaugfläche "b" durch die größere dortige Fläche "b" kompensiert wird, denn wie aus Fig. 1 ersichtlich, nimmt die Faserauflage in Förderrichtung 9 zu. Hierdurch ist es auch möglich, mit gegenüber herkömmlichen Fallschächten geringeren Saugdrücken zu arbeiten, wodurch die Querströmungen über dem sich bildenden Vlies weitgehend vermieden werden.

Daß man spiegelbildlich zu der in Fig. 1 gezeigten Sammelfördereinheit 6 statt dem Leitblech 13 eine entsprechende Sammelfördereinheit vorsieht, ist ebenfalls möglich.

In Fig. 2 ist schematisch vereinfacht ein Schnitt durch ein zweites Ausführungsbeispiel einer erfindungsgemäßen Einrichtung, und zwar mit vier Zerfaserungseinheiten 14 bis 17, einem Fallschacht 18 und zwei gegenläufig antreibbaren Sammelförderern 19 und 21 in Form von Trommeln sowie eine diesen nachgeschaltete, entsprechend dem Pfeil 20 verstellbare Abdichtwalze 22 gezeigt. Bei dieser Einrichtung wird aus zwei Teilvliesen 23 und 24 kontinuierlich ein Gesamtvlies 25 erzeugt, wobei die trommelartigen Sammelförderer 19, 21 mit einem festen Achsabstand zueinander angeordnet sind. Da deshalb der lichte Abstand zwischen den beiden Sammelförderern 19, 21 auch konstant ist, übernimmt die Walze 22 quasi die Funktion einer einstellbaren Abdichteinrichtung am mit 26 bezeichneten Austragsspalt.

Auch hier ist deutlich zu erkennen, daß die Absaugfläche zu Beginn der Bildung des Teilvlieses 23, bezeichnet mit "c", kleiner ist als die mit "d" bezeichnete Absaugfläche im Bereich der höheren Faserauflage des Teilvlieses 23. Diese Absaugflächen "c" und "d" können insbesondere im Bereich des Austragsspaltes 26 variabel eingestellt werden, um optimale Austrag- und Absaugverhältnisse erhalten zu können. Diese Einstellbarkeit erfolgt durch einen z. B. im Inneren der Trommel 19 vorgesehenen Stator 27, mit dem man den besaugten und nichtbesaugten Teil der Trommel voneinander trennen kann. Ziel ist dabei, daß die beiden Teilvliese 23 und 24 vor dem Austrag zusammengeführt werden. Der Sammelförderer 21 ist im Prinzip ähnlich aufgebaut wie der Sammelförderer 19, d. h., er hat ebenfalls einen Stator 28, mit dem der besaugte und nichtbesaugte Teil voneinander getrennt wird. Lediglich der besaugte Teil endet hier früher als bei dem gegenüberliegenden Sammelförderer 19, da das Teilvlies 24 infolge der abdichtenden Walze 22 früher von dem Sammelförderer 21 abheben muß. Dieses Abheben kann auch durch eine in Fig. 2 schematisch dargestellte Abblasevorrichtung 30 wesentlich erleichtert werden.

In Fig. 3 ist ebenfalls schematisch vereinfacht ein drittes Ausführungsbeispiel mit zwei trommelartigen Sammelförderern 29 und 31, mit denen Teilvliese 32 und 33 gebildet werden, dargestellt. Gegenüber der in Fig. 2 dargestellten Einrichtung unterscheidet sich diese Einrichtung zur kontinuierlichen Herstellung eines Mineralwollevlieses 34 lediglich dadurch, daß dieses durch in Förderrichtung nachgeschaltete Zwillingswalzen 35 und 36 gebildet wird, wobei letztere einstellbar ausgebildet sind, was durch die Pfeile 37 und 38 angedeutet ist. Die Zwillingswalzen können dabei entsprechend der Darstellung in Fig. 3 symmetrisch aber auch unsymmetrisch zu den Sammelförderern 29, 31 angeordnet sein.

Auch hier besitzt jeder Sammelförderer 29 bzw. 31 einen inneren Stator 39 bzw. 41, mit dem die besaugten bzw. nichtbesaugten Teile der Sammelförderer eingestellt werden können. Im vorliegenden Fall ist bei beiden Sammelförderern 29, 31 jeweils die gesamte besaugte Fläche gleich groß, wobei die zur Verfügung stehenden Absaugflächen für die einzelnen Zerfaserungseinheiten, bezeichnet mit "e" und "f", in Förderrichtung wieder zunehmen.

Für den Fall einer kontinuierlichen Herstellung einer aus mehreren Einzelvliesen 42 und 43 zusammengesetzten Filzbahn 44 sind in Fig. 4 zwei hintereinander angeordnete Einrichtungen gemäß Fig. 3 dargestellt, die jedoch hier jeweils als viertes Ausführungsbeispiel statt mit den Walzen 35, 36 mit zwei Förderbändern 45 bis 48 ausgestattet sind, deren Abstand zueinander veränderbar ist. Insbesondere bei Einzelvliesen mit einer relativ niedrigen Rohdichte, beispielsweise unter 20 kg/m^3, übernehmen die Förderbänder 45 bis 48 eine gewisse Führung der Einzelvliese. Aus der Fig. 4 ist deutlich zu erkennen, wie das Einzelvlies 42 als erstes auf ein laufendes Produktionsband 49 abgelegt und dann auf dieses Einzelvlies 42 später das Einzelvlies 43 aufgelegt wird, so daß das Gesamtvlies 44 entsteht. Dieses Beispiel kann selbstverständlich dahingehend erweitert werden, daß man weitere Einzelvliese als Auflage hinzufügt.

Schließlich ist in Fig. 5 perspektivisch schematisch ein Ausschnitt aus einer Fertigungslinie, mit der kontinuierlich eine aus mehreren Vliesschichten 51 zusammengesetzte Filzbahn 52 hergestellt wird, dargestellt. Die einzelnen Vliesschichten 51 stammen von einem einzigen Vlies 53, das z. B. entsprechend dem Einzelvlies 42 in Fig. 4 hergestellt worden ist. Die hier in einem veränderbaren Abstand zueinander angeordneten Förderbänder 54 und 55 entsprechen dabei den Förderbändern 45 und 46 in Fig. 4, wogegen in diesem fünften Ausführungsbeispiel die Förderbänder 54 und 55 eine pendelnde Bewegung ausführen können, um das Einzelvlies 53 auf einem umlaufenden Produktionsband 56 zu der mehrschichtigen Filzbahn 52 ablegen zu können. Der Mechanismus, der die Förderbänder 54 und 55 in eine pendelnde Bewegung versetzt, ist in der Zeichnung nicht dargestellt; er ist vielmehr symbolisch durch den Doppelpfeil 57 lediglich angedeutet.

Ganz allgemein sind die Sammelförderer aller fünf Ausführungsbeispiele jeweils mit einer eigenen regelbaren Absaugung bzw. bei einer gemeinsamen Absaugung mit einem entsprechenden Drosselorgan ausgestattet, und zwar, um auf eventuell stillstehende Zerfaserungseinheiten und unterschiedliche Anforderungen an die Absaugung reagieren zu können. Ferner ist es auch möglich, daß ein Sammelförderer durch mehr als zwei Zerfaserungseinheiten beaufschlagt wird, da das erfindungsgemäße Konzept vorteilhaft erlaubt, bei relativ geringer Absaugenergie mit relativ hohen Faserauflagen zu arbeiten.

Patentansprüche

1. Verfahren zur kontinuierlichen Herstellung von Mineralwollevliesen, bei dem zur Bildung der Vliese in einem Fallschacht mehrere Zerfaserungseinheiten vorgesehen sind und bei dem die Fasern unter Wirkung eines Saugdruckes auf mindestens einem Sammelförderer abgelegt werden, **dadurch gekennzeichnet,** daß die Ablage der Fasern auf einer der jeweiligen Zerfaserungseinheit zugeordneten und in Förderrichtung jeweils zunehmenden Ablagefläche des Sammelförderers erfolgt.

2. Einrichtung zur Durchführung des Verfahrens nach Anspruch 1, insbesondere zur Herstellung von Mineralwollevliesen aus Steinwolle, welche zur Bildung der Vliese in einem Fallschacht mehrere Zerfaserungseinheiten aufweist, und bei der die Fasern auf einer gasdurchlässigen Sammelfördereinheit mit mindestens einem gekrümmt verlaufenden Bereich unter Wirkung eines Saugdruckes ablegbar sind, wobei im Abstand zu dem gekrümmt verlaufenden Bereich mindestens ein in bezug auf den Fallschacht abdichtendes Leitelement angeordnet ist, **dadurch gekennzeichnet,** daß jedem von den einzelnen Zerfaserungseinheiten (1, 2; 14 bis 17) gebildeten Faser-/Gas-/Luft-Gemisch eine fiktive Absaugfläche auf dem gekrümmt verlaufenden Bereich der Sammelfördereinheit (6; 19, 21; 29, 31) derart zugeordnet ist, daß die zur Verfügung stehenden Absaugflächen (a, b; c, d; e, f) für die einzelnen Zerfaserungseinheiten (1, 2; 14 bis 17) in Förderrichtung zunehmen.

3. Einrichtung nach Anspruch 2, **dadurch gekennzeichnet,** daß das Leitelement (13) mit seiner dem gekrümmt verlaufenden Bereich gegenüberliegenden Fläche in Förderrichtung bewegbar ausgebildet ist.

4. Einrichtung nach Anspruch 2 oder 3, **dadurch gekennzeichnet,** daß der lichte Abstand (12) zwischen dem Leitelement und der Sammelfördereinheit einstellbar ist.

5. Einrichtung nach einem der Ansprüche 2 bis 4, **dadurch gekennzeichnet,** daß anstelle des Leitelementes (13) eine weitere Sammelfördereinheit vorgesehen ist.

6. Einrichtung nach Anspruch 5, **dadurch gekennzeichnet,** daß den zwei Sammelfördereinheiten mindestens drei Zerfaserungseinheiten zugeordnet sind.

7. Einrichtung nach Anspruch 5 oder 6, **dadurch gekennzeichnet,** daß der zwischen den Sammelfördereinheiten zum Austragen des Vlieses vorgesehene Spalt in seiner Breite veränderbar ist.

8. Einrichtung nach einem der Ansprüche 5 bis 7, **dadurch gekennzeichnet,** daß der zwischen den Sammelfördereinheiten zum Austragen des Vlieses vorgesehene Spalt (26) durch mindestens ein in Förderrichtung nachgeschaltetes verstellbares Element (22) in seiner Breite veränderbar ist.

9. Einrichtung nach Anspruch 8, **dadurch gekennzeichnet,** daß als verstellbares Element (22) eine antreibbare Walze oder ein antreibbares Förderband dient.

10. Einrichtung nach Anspruch 8, **dadurch gekennzeichnet,** daß als verstellbares Element zwei antreibbare, in einem veränderbaren Abstand zueinander angeordnete Walzen (35, 36) oder Förderbänder (45, 46) dienen.

11. Einrichtung nach einem der Ansprüche 2 bis 10, **dadurch gekennzeichnet,** daß die zur Verfügung stehenden Absaugflächen (a, b; c, d; e, f) jeder Sammelfördereinheit (6; 19, 21; 29, 31), insbesondere im Bereich des zum Austragen des Vlieses vorgesehenen Spaltes, in ihrer Größe einstellbar sind.

12. Einrichtung nach einem der Ansprüche 8 bis 11, **dadurch gekennzeichnet,** daß mindestens vor einem nachgeschalteten Element (22) mindestens eine Abblasevorrichtung (30) vorgesehen ist, durch welche die sich bildenden Vliese manipulierbar sind.

13. Einrichtung nach einem der Ansprüche 2 bis 12, **dadurch gekennzeichnet,** daß zur Erzeugung der vliesbildenden Fasern nach dem Düsenblasverfahren arbeitende Zerfaserungseinheiten (1, 2; 14 bis 17) dienen.

14. Einrichtung nach Anspruch 13, **dadurch gekennzeichnet,** daß die Zerfaserungseinheiten derart geneigt angeordnet sind, daß die von diesen erzeugten Fasern unter einem von der Senkrechten abweichenden Neigungswinkel auf die Sammelflächen auftreffen.

15. Einrichtung nach einem der Ansprüche 2 bis 14, **dadurch gekennzeichnet,** daß mindestens eine Sammelfördereinheit (19) als Trommel ausgebildet ist.

16. Einrichtung nach mindestens einem der Ansprüche 2 bis 15, **dadurch gekennzeichnet,** daß der Saugdruck in jeder Sammelfördereinheit (6; 19, 21; 29, 31) für sich regelbar ist.

17. Verfahren zur kontinuierlichen Herstellung einer aus mehreren Einzelvliesen zusammengesetzten Filzbahn, insbesondere aus Einzelvliesen, die mit einer Einrichtung nach den Ansprüchen 2 bis 16 gebildet worden sind, **dadurch gekennzeichnet,** daß von mehreren Einrichtungen kommende Einzelvliese (42, 43) gemeinsam auf einem laufenden Produktionsband (49) zu einer Filzbahn (44) abgelegt werden.

18. Verfahren zur kontinuierlichen Herstellung einer aus mehreren Vliesschichten zusammengesetzten Filzbahn, insbesondere aus einem Vlies, das mit einer Einrichtung nach den Ansprüchen 2 bis 16 gebildet worden ist, **dadurch gekennzeichnet,** daß das Vlies (53) auf einem laufenden Produktionsband (56) durch eine pendelnde Bewegung (57) auf diesem zu der mehrschichtigen Filzbahn (52) abgelegt wird.

Claims

1. Process for continuous production of mineral wool nonwoven fabrics, in which for the formation of nonwoven fabrics in a fall shaft several shredding units are provided and in which the fibers under the effect of a suction pressure are deposited on at least one collecting conveyor, characterized in that the deposit of the fibers takes place on a deposit surface of the collecting conveyor assigned to the respective shredding unit and increasing in each case in the conveying direction.

2. Device for performing the process according to claim 1, especially for the production of mineral wool nonwoven fabrics from rock wool, which for the formation of the nonwoven fabrics exhibits in a fall shaft several shredding units, and in which the fibers can be deposited under the effect of a suction pressure on a gas-permeable collecting conveyor unit with at least one area running in a curve, and at least one guide element, sealing in regard to the fall shaft, is placed at a distance from the area running in a curve, wherein an imaginary suction surface of the area of the collecting conveyor unit running in a curve (6; 19, 21; 29, 31) is assigned to each fiber/gas/air mixture formed by the individual shredding units (1, 2; 14 to 17) so that the available suction surfaces (a, b; c, d; e, f) for individual shredding units (1, 2; 14 to 17) increase in the conveying direction.

3. Device according to claim 2, wherein guide element (13) is designed movable in the conveying direction with its surface opposite the area running in a curve.

4. Device according to claim 2 or 3, wherein clearance distance (12) between the guide element and the collecting conveyor unit is adjustable.

5. Device according to one of claims 2 to 4, wherein another collecting conveyor unit is provided instead of guide element (13).

6. Device according to claim 5, wherein at least three shredding units are assigned to the two collecting conveyor units.

7. Device according to claim 5 or 6, wherein the slot provided between the collecting conveyor units for discharge of the nonwoven fabric is

variable in its width.

8. Device according to one of claims 5 to 7, wherein slot (26) provided between the collecting conveyor units for discharge of the nonwoven fabric is variable in its width by at least one adjustable element (22) downstream in the conveying direction.

9. Device according to claim 8, wherein a drivable roller or a drivable conveyor belt is used as adjustable element (22).

10. Device according to claim 8, wherein two drivable rollers (35, 36) or conveyor belts (45, 46), placed at a variable distance from one another, are used as adjustable element.

11. Device according to one of claims 2 to 10, wherein available suction surfaces (a, b; c, d; e, f) of each collecting conveyor unit (6; 19,21; 29, 31), especially in the area of the slot provided for discharge of the nonwoven fabric, are adjustable in their size.

12. Device according to one of claims 8 to 11, wherein in front of a downstream element (22) at least one blast device (30) is provided by which the forming nonwoven fabrics can be manipulated.

13. Device according to one of claims 2 to 12, wherein shredding units (1, 2; 14 to 17), operating according to the blast drawing process are used for the production of the fibers forming nonwoven fabrics.

14. Device according to claim 13, wherein the shredding units are inclined so that the fibers produced by them strike the collecting surfaces at an inclination deviating from the vertical.

15. Device according to one of claims 2 to 14, wherein at least one collecting conveyor unit (19) is designed as a drum.

16. Device according to at least one of claims 2 to 15, wherein the suction pressure in each collecting conveyor unit (6; 19, 21; 29, 31) is adjustable by itself.

17. Process for the continuous production of a felt web composed of several individual nonwoven fabrics, especially from individual nonwoven fabrics, which are formed with a device according to claims 2 to 10, wherein individual nonwoven fabrics (42, 43) coming from several devices are deposited together on a running production belt (49) into a felt web (44).

18. Process for the continuous production of a felt web composed of several nonwoven fabric layers, especially from a nonwoven fabric, which was formed with a device according to claims 2 to 16, wherein nonwoven fabric (53) is deposited on a running production belt (56) by a oscillating movement (57) on it into a multilayer felt web (52).

Revendications

1. Procédé de fabrication continu de nappes de laine minérale suivant lequel, en vue de la formation des nappes, plusieurs unités de formation de fibres sont prévues dans une hotte et les fibres sont déposées sous l'effet d'une dépression sur au moins un transporteur collecteur, caractérisé en ce que le dépôt des fibres est réalisé sur une surface de dépôt du transporteur collecteur qui est associée à l'unité de formation de fibres correspondante et qui va en augmentant dans le sens du transport.

2. Dispositif pour l'exécution du procédé suivant la revendication 1, en particulier pour la fabrication de nappes de laine minérale à partir de laine de roche qui comporte, en vue de la formation des nappes, plusieurs unités de formation de fibres dans une hotte et dans lequel les fibres peuvent être déposées sur une unité transporteuse collectrice perméable aux gaz présentant au moins un domaine à allure courbe, sous l'effet d'une dépression, au moins un élément de guidage assurant l'étanchéité par rapport à la hotte étant prévu à une certaine distance du domaine à allure courbe, caractérisé en ce qu'une surface d'aspiration fictive sur le domaine à allure courbe de l'unité transporteuse collectrice (6, 19, 29, 31) est affectée à chacun des mélanges de fibres, de gaz et d'air formés par les unités de formation de fibres individuelles (1, 2, 14 à 17) d'une manière telle que les surfaces d'aspiration (a, b; c, d; e, f) disponibles pour les unités de formation de fibres (1, 2, 14 à 17) individuelles aillent en augmentant dans le sens du transport.

3. Dispositif suivant la revendication 2, caractérisé en ce que l'élément de guidage (13) est monté mobile dans le sens du transport par sa face opposée au domaine à allure courbe.

4. Dispositif suivant la revendication 2 ou 3, caractérisé en ce que l'espace libre (12) entre l'élément de guidage et l'unité transporteuse

collectrice est réglable.

5. Dispositif suivant l'une quelconque des revendications 2 à 4, caractérisé en ce qu'une autre unité transporteuse collectrice est prévue en lieu et place de l'élément de guidage (13).

6. Dispositif suivant la revendication 5, caractérisé en ce qu'au moins trois unités de formation de fibres sont associées aux deux unités transporteuses collectrices.

7. Dispositif suivant la revendication 5 ou 6, caractérisé en ce que la fente prévue entre les unités transporteuses collectrices pour l'évacuation de la nappe est réglable en largeur.

8. Dispositif suivant l'une quelconque des revendications 5 à 7, caractérisé en ce que la fente (26) prévue entre les unités transporteuses collectrices pour l'évacuation de la nappe est réglable en largeur par au moins un élément réglable (22) monté en aval dans le sens du transport.

9. Dispositif suivant la revendication 8, caractérisé en ce qu'un cylindre entraînable ou une bande transporteuse entraînable sert d'élément réglable (22).

10. Dispositif suivant la revendication 8, caractérisé en ce que deux cylindres (35, 36) ou deux bandes transporteuses (45, 46) entraînables et montés à distance réciproque réglable servent d'élément réglable.

11. Dispositif suivant l'une quelconque des revendications 2 à 10, caractérisé en ce que les surfaces d'aspiration (a, b; c, d; e, f) disponibles de chaque unité transporteuse collectrice (6; 19, 21; 29, 31) sont réglables en grandeur en particulier dans le domaine de la fente prévue pour l'évacuation de la nappe.

12. Dispositif suivant l'une quelconque des revendications 8 à 11, caractérisé en ce qu'au moins en amont d'un élément (22) monté en aval est prévu au moins un dispositif de soufflage (30) permettant de manipuler la nappe en formation.

13. Dispositif suivant l'une quelconque des revendications 2 à 12, caractérisé en ce que des unités de formation de fibres (1, 2, 14 à 17) fonctionnant suivant le procédé d'étirage par soufflage servent à produire les fibres formant les nappes.

14. Dispositif suivant la revendication 13, caractérisé en ce que les unités de formation de fibres sont montées inclinées de manière que les fibres qu'elles produisent arrivent sur les surfaces collectrices sous un angle différent de 90°.

15. Dispositif suivant l'une quelconque des revendications 2 à 14, caractérisé en ce qu'au moins une unité transporteuse collectrice (19) a la forme d'un tambour.

16. Dispositif suivant au moins l'une des revendications 2 à 15, caractérisé en ce que la dépression est réglable individuellement dans chaque unité transporteuse collectrice (6; 19, 21; 29, 31).

17. Procédé de fabrication continue d'une bande de feutre composée de plusieurs nappes individuelles, en particulier, de nappes individuelles qui ont été formées au moyen d'un dispositif suivant les revendications 2 à 16, caractérisé en ce que des nappes individuelles (42, 43) provenant de plusieurs dispositifs sont déposées ensemble sur une bande de production (49) en mouvement pour former une bande de feutre (44).

18. Procédé de fabrication continue d'une bande de feutre composée de plusieurs couches de nappes, en particulier à partir d'une nappe qui a été formée au moyen d'un dispositif suivant les revendications 2 à 16, caractérisé en ce que la nappe (53) est déposée sur une bande de production (56) en mouvement par un mouvement alternatif (57) pour former une bande de feutre (52) à plusieurs couches.

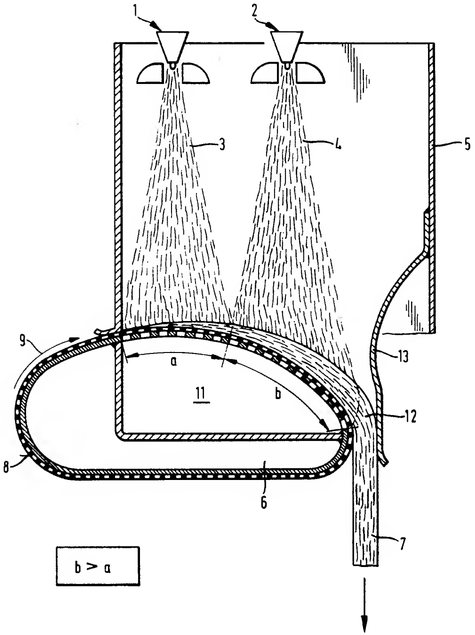

Fig. 1

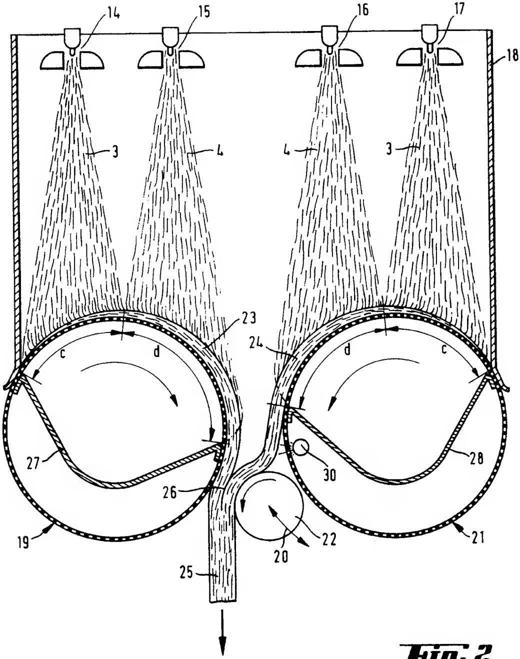

Fig. 2

d > c

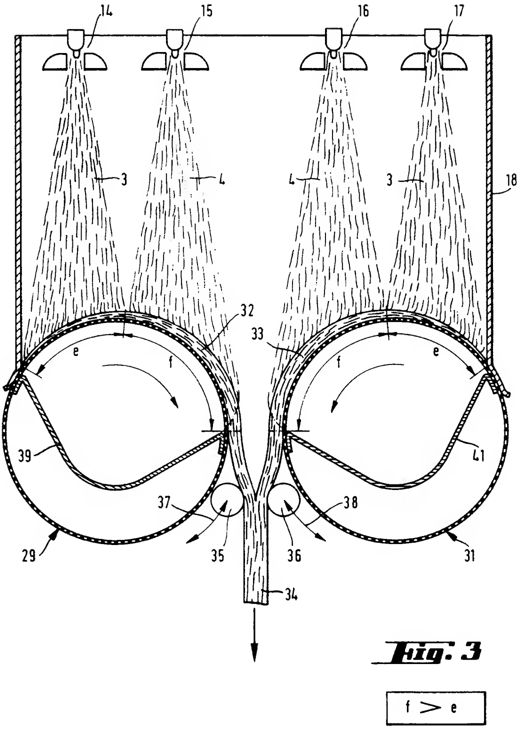

Fig. 3

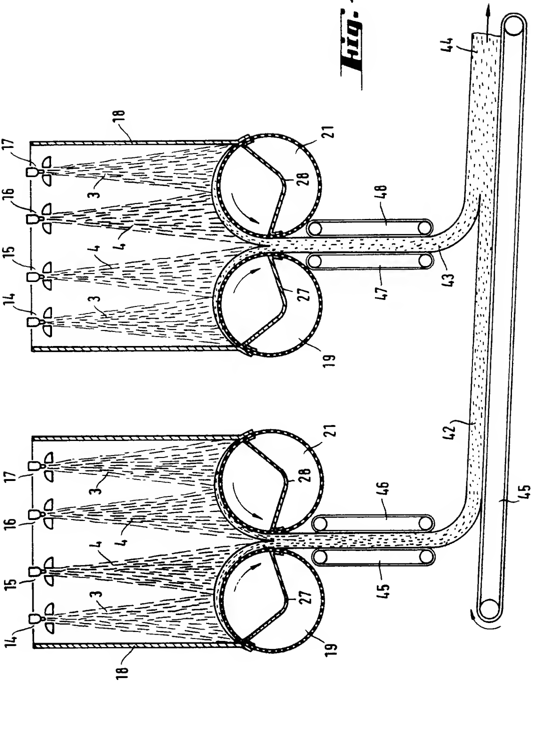

Fig. 4

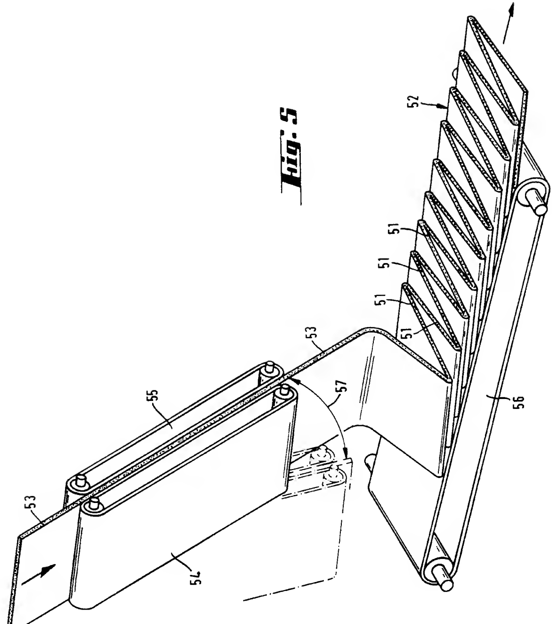

Fig. 5

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(54) Melt blowing method for forming a fibrous layered web of filter media, melt blowing apparatus and a layered filter media web product

(57) A method, die apparatus and product wherein a layered web of melt blown fibrous filter media is produced by a unitary die including several die sources with facing layers of the fibrous filter media being attenuated by opposed fluid streams at preselected included angles and with the fiber layers being free from bonding together and with the fibers in each layer being minimally bonded.

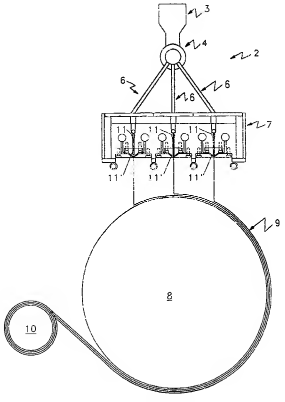

FIG. 1

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Description

BACKGROUND OF THE INVENTION

The present invention relates to a method, apparatus and product involving melt blowing systems and more particularly to an improved, highly efficient, low energy melt blowing process, a novel melt blowing die apparatus having a unique capability of accomplishing such process with a minimum of structural parts and a minimum of energy and a novel, highly efficient filter media product which can be readily produced by the inventive process and apparatus.

Non woven fiber mats formed by melt blowing dies and melt blowing processes for producing the same have been long known in the prior art. In this regard, attention is directed to the expired U.S. patent No. 3,825,380, issued to J.W. Harding et al on July 23, 1974, which teaches the formation of such a fibrous mat from molten polymers by means of a longitudinally extending die apparatus having a triangular cross-sectional die nose configuration with a pair of oppositely directed attenuating air streams being directed along the die nose flanks toward centrally emitted melt blown fibers with the air streams flowing in opposed angular direction so as to include an angle therebetween in the range of thirty (30) to ninety (90) degrees, it being noted that the attenuated elongated fiber streams are cooled ambiently before collection on a screen as a web. In U.S. patent No. 4,714,647, issued to P.W. Shipp, Jr. et al on December 22, 1987, sequentially deposited layers of melt blown thermoplastic filter fibers of different sizes are collected as a laminate web and in U.S. patent No. 5,236,641, issued to M.A. Allen et al on August 17, 1993 melt blown polymer fibers are fed as strips to a collector by individually fed side-by-side melt blowing units, each unit having its through-put controlled to maintain the property in each strip at a predetermined value. Finally attention is directed to U.S. Patents No. 4,486,161, issued to D.L. Middleton on December 4, 1984; No. 4,818,463, issued to P.G. Buehning on April 4, 1989; and No. 4,986,743, issued to P.G. Buehning on January 22, 1991, each of which three aforesaid patents teaches a die tip structural arrangement for melt blown fiber material feeding.

Although the prior art teaches or suggests various overall die structures, die tip fluid material feeding structure and melt blowing processes, none teaches the unique and novel die construction, melt blowing process and resulting layered, fibrous filter web as is described herein.

In accordance with the novel features of the present invention, a straightforward, economical, easy to manufacture, easy to assemble and to maintain apparatus is provided, as is a unique melt blowing process requiring a straightforward and economical series of steps which provides an increase in fibrous filter media output with a minimum of energy consumption. In addition the present invention allows for straightforward and economical modifications in the novel process, apparatus and product to produce varying sizes and varying characteristic filter fibers in accordance with varying market demands. Further, the present invention provides a unique layered fibrous filter mat which serves to increase bulk with accompanying increased dust holding capacity and overall filtering efficiency.

Various other features of the present invention will become obvious to one skilled in the art upon reading the disclosure set forth herein.

BRIEF SUMMARY OF THE INVENTORY

More particularly the present invention provides a process for forming a layered web of fibrous filter media wherein adjacently facing layers of fibrous filter media are distinctly separate from each other comprising: sequentially feeding filter media fibers in heated and fiber attenuated form from heated melt blown die source orifices toward a spaced collector source to be layered as at least two separate and distinct layers of fibrous filter media onto the collector source with one fibrous filter media layer being on top of the other in faced relation; and, treating the fibers of the facing layers of fibrous filter media between the die source and before the collector source in order to enhance crystallization and to avoid bonding between adjacent media layer faces and to reduce bonding within each of the layers to increase the layered web of fibrous filter media in bulk with accompanying increased dust holding capacity and overall filtration efficiency. Further, the present invention provides a preselected included angle for fiber attenuating fluid streams wherein such attenuating fluid streams on either side of a fluid material stream are more in opposition to each other to provide a high velocity, turbulent, pulse-like sinusoidal flow from the fluid material outlet to increase the rate of fiber attenuation. In addition, the present invention provides a die apparatus for forming a layered web of fibrous filter media with the layers thereof distinctly separate from each comprising: a unitary die body formed from a preselected heat conductive material, the die body having formed therein at least two preselectively spaced fluid material flow-through passages, each material flow-through passage having a fluid material receiving inlet and a fluid material dispensing outlet adapted to dispense a row of layer forming fibers therefrom with the dispensed randomly oriented fiber layers to be collected in stacked, facing relation; the die body further having formed therein at least two pairs of oppositely disposed fluid attenuating flow-through passages, each having a fluid attenuating outlet with the oppositely disposed fluid attenuating outlets of each pair of fluid attenuating passages being disposed at preselectively opposed angles to define a preselected include angle in excess of approximately ninety-five (95) degrees so that the fluid attenuating outlet pairs are so angularly positioned relative each of the fluid material outlets to be more in opposition to each other to provide a

high velocity, turbulent, pulse-like, sinusoidal attenuated fibrous flow from each of the fluid material outlets to thus increase the rate of fibrous layer attenuation; a heating means cooperative with the unitary die body whereby heat is conducted to the fluid material passages and the fluid attenuating passages; and, an insulating means cooperative with the heating means to appropriately insulate portions of the same. In addition, the present invention provides fluid treating passages cooperative with the fluid outlets to treat the layered fibrous material so as to avoid subsequent bonding between collected adjacent facing fibrous layers and to reduce bonding of fibers within each layer thus increasing layered fibrous filter media web bulk with accompanying increased dust holding capacity and overall filtering efficiency.

Finally, the present invention provides a unique, layered, fibrous fluid filter media web of melt blown fibrous material comprising; at least two freely separable face-to-face melt blown layers of fibrous filter media free of face-to-face layer bonding with the fibers in each layer having a minimum bonded relation to each other, providing a layered fibrous filter media of increased bulk with accompanying increased dust holding capacity and overall filtering efficiency.

It is to be understood that various changes can be made by one skilled in the art in one or more of the process steps and in one or more of the several parts of the die apparatus and resulting product without departing from the scope or spirit of the present invention. For example, it would be possible with a mere ready change of nose and lip sections to vary the cross-sectional geometry and fiber count produced and to vary fiber diameter from one die source to an adjacent die source, all within a unitary die source body.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings which schematically disclose one advantageous embodiment of the present invention:

Figure 1 is a schematic cross-sectional view of the overall structure incorporating the inventive unitary melt blown die body and a drum collector positioned in spaced relation therebelow to receive and collect melt blown fibrous layers in a facing layer-upon-layer web;

Figure 2 is an enlarged cross-sectional view of the novel die body structure of Figure 1;

Figure 3 is an isometric view of the unique die body disclosed in Figures 1 and 2 with the spaced, removable nose sections and fluid passage lip sections of Figures 1 and 2 removed; and,

Figure 4 is a cross-sectional view taken in a plane through line 4-4 of the enlarged view of Figure 2, disclosing in longitudinal form the fluid material feed structure in cooperation with a spinneret orifice plate in the removable nose sections.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 1 of the schematic drawings, a spinning assembly 2 is schematically disclosed as including a fluid material feed hopper 3, a motor driven (not shown) extruder 4, fluid material feeder conduits 6, the inventive unitary die body 7 and a spaced fibrous web rotating drum collector 8 for collecting the novel layered fibrous web 9 thereon to be fed to winder 10, the overall spinning assembly 2 including a feed hopper, extruder, feeder conduits, die body, collector - either of drum or endless belt type - and winder being generally known in the art.

Referring to the enlarged schematic arrangement of Figures 2-4 of the drawings, details of the inventive features of the novel die apparatus and process for forming the novel layered web of fibrous filter media 9 can be seen in detail. In accordance with the present invention, longitudinally extending unitary die body 7 can be formed as such unitary die body member (Fig. 3) from a suitable, preselected heat conducting material, such as a nickel-chromium steel, it being understood that other types of suitable, readily formed, heat conductive materials also could be utilized. Unitary longitudinally extending die body 7 has formed therein, either by precision casting or precision drilling, a plurality of preselectively spaced fluid material flowthrough slotted material passages 11, three such slotted material passages being shown in the drawings. In order to provide for a final layered product, it is to be understood that at least two such slotted fluid material flow-through passages are required in the longitudinally extending, unitary die body with the spacing of the slotted material passages 11 being compatible with the geometry and size of drum 8 or an endless belt collector (not shown). Each fluid material slotted passage 11 has a fluid material receiving inlet 12 to be connected to the aforedescribed feed hopper 3, extruder 4 and one of feeder conduits 6 disposed externally of unitary die body 7. Each fluid material slotted passage 11 is further provided with a fluid material slotted dispensing outlet 13, which outlet is located in the communicating removable nose section as described more fully hereinafter. The longitudinally extending unitary die body 7 further is provided with pairs of oppositely disposed rows of spaced fluid attenuating flow-through passages 14 with one pair of opposed rows of spaced attenuating passages 14 serving the opposite sides of each fluid material slotted flow-through passage 11 in die body 7. Like slotted flow-through material passages 11, each pair of rows of spaced passages 14 serving as oppositely disposed slotted fluid attenuating passages can be formed in unitary die body 7 by precision casting or precision cutting. Each spaced fluid attenuating flow-through passage 14 of each pair of spaced rows is provided with a fluid attenuating manifold inlet 16 connected to a suitable pressured air source external of die body 7 and not shown and a fluid attenuating outlet 17. As is described more fully hereinafter, opposed fluid at-

tenuating outlet pairs 17 (Figure 2) are formed by the flanks of a removable, longitudinally extending nose section of triangular cross-section and one pair of oppositely disposed and spaced mirror-image removable longitudinally extending lip sections.

Referring particularly to Figure 3 of the drawings, it can be seen that one side of longitudinally extending unitary die body 7 is provided with three longitudinally extending, cross-sectionally stepped recesses 18. Each of these longitudinally extending stepped recesses 18 serves to snugly receive in nesting relation the longitudinally extending base portion 21 of a longitudinally extending nose section 19, which nose section 19 also can be formed as a single, unitary piece from a suitable heat conductive material such as nickel-chromium steel similar to the material of unitary longitudinally extending unitary die body 7. Each longitudinally extending nose section 19 is appropriately provided with a plurality of spaced taps 22 through the longitudinally extending side wing portions of longitudinally extending nose section 19 to receive in nesting relation the heads of fastening screws 23 which engage in the spaced taps 24 in longitudinally extending unitary die body 7.

As can be seen in Figure 2 of the drawings, each longitudinally extending nose section 19 is so formed as to provide a longitudinally extending apex portion 26 extending from nestable base portion 21, this apex portion 26 also is centrally longitudinally slotted as at 11' so as to mate with and provide a communicating continuation of longitudinally extending fluid material dispensing slot 11 in longitudinally extending unitary die body 7 with the fluid material outlet 13 of slot 11' being adjacent the apex of the nose section to cooperate with an orificed longitudinally extending spinnerette plate mounted at the apex of longitudinally extending nose section 19 (described hereinafter).

It is to be noted that longitudinally extending apex portion 26 of longitudinally extending nose section 19 is of triangular cross-section with the included angle defining the apex of the cross-sectional triangle being preselectively in excess of ninety-five (95) degrees. It is recognized that the nose section thickness and strength to prevent cracking near the tip vicinity of the nose section orifice increases as the included angle increases.

In accordance with the present invention the included angle of the triangular cross-section is selectively in the range of approximately ninety-five (95) degrees to one hundred and twenty (120) degrees and advantageously is approximately one hundred and eight (108) degrees plus or minus two (2) degrees. Since the oppositely and inwardly sloping side flanks of the longitudinally extending apex portion 26 of longitudinally extending nose section 19 each serve as one defining wall of the opposed terminal portion of fluid attenuating passages 14 and the cooperating parallel and chamfered spaced edge end faces of opposed mirror-image longitudinally extending removable lip sections 27 serve as the other defining walls of the terminal portions of passages 14, the defined fluid attenuating outlets 17 are so angularly positioned on opposite sides of fluid material outlets 13 as to be more in opposition to each other to provide a turbulent pulse-like, sinusoidal attenuating fibrous flow from each of fluid material outlets 13 to thus increase the rate of fibrous layer attenuation from each outlet 13 in accordance with one feature of the present invention. In accordance with still another feature of the present invention, the removable longitudinally extending lip sections 27, as can be seen in Figure 2 and 3 are each provided with longitudinally spaced, tapped recesses 28 adjacent the side opposite the chamfered end edge of each of the opposed lip sections. These tapped recesses 28 serve to receive the heads of fastening screws 29, which like screws 23, engage in spaced taps 31 of unitary die body 7 to hold the removable lip section pairs 27 in fast passage defining position. It is to be understood that the spacing and geometric configuration of the lip sections 27 can be varied to determine the velocity and angle of the fluid attenuating stream.

As can be seen in Figure 4 of the drawings, the cross-section of each of the longitudinally extending slot type fluid material flow-through passages 11 is formed in unitary die body 7 in a hanger type shape, such a hanger-type shape for fluid material passages being long known in the art. As aforedescribed elongated, slotted passages 11 communicate with passages 11' in nose sections 19 when they are removably mounted in the stepped recess 18 of the unitary die body 7. Formed in the apex portion 26 of each nose section 19, also in a manner known in the art, is an orifice plate 32. Each orifice plate 32 includes at least one row of spaced fibrous fluid emitting apertures therein. In accordance with still another feature of the present invention, these spaced apertures advantageously number approximately thirty (30) per inch, each being preselectively sized and geometrically shaped to determine the size and cross-sectional shape of the layered fibrous material passing therethrough. It is to be understood that like lip section pairs 27, the nose sections 19 can be readily replaced with other type lip and nose sections having differing designs including but not limited to geometrically differing orifice arrangements and sizes.

Referring once again to Figure 1 of the drawings, it can be seen that unitary die body 7, can advantageously be provided with an aluminum alloyed, electric coil heating jacket 33 cooperatively surrounding the unitary die body 7 to conduct heat to fluid passages 11 and 14 therein. A suitable ceramic insulating jacket 34 cooperatively surround the outer face of heating jacket 33. It is to be understood that the present invention is to be considered as not limited to the specific heating and insulating arrangements as shown but that other heating and insulating arrangements can be employed without departing from the scope or spirit of the invention disclosed herein.

In accordance with still another feature of the present invention, as can also be seen in Figure 1,

spaced, apertured fluid conduits 36 can be fastened to the unitary die body 7 to be cooperative along opposite sides of each fluid material dispensing outlet 13 at the apex of nose section 19 and opposed lip sections 27 to treat emitted layered fibrous material with a solidifying, cooling fluid such as blower driven cool or ambient air. Such a solidifying treatment serves to avoid subsequent bonding of collected adjacent facing fibrous layers and to reduce the bonding of individual fibers within each layer to thus increase media bulk with accompanying increased dust holding capacity and overall efficiency.

In carrying out the inventive process for forming a layered web of fibrous filter media wherein adjacently facing layers of fibrous filter media are distinctly separate from each other, polymer filter media fibers are sequentially fed in heated form, the polymer media advantageously having a viscosity in the range of at least ten (10) to three hundred (300) poise. The polymer is fed from at least two and advantageously several preselected spaced heated melt blown die source orifice rows as fiber forming layers with at least ten (10) to fifty (50) fibers per inch and advantageously and at least approximately thirty (30) fibers per inch with the fibers having been heated in the melt blown die sources to a temperature within the approximate range of four hundred (400 F) to nine hundred (900 F) degrees Fahrenheit. The output of melt blown material per each orifice of a die source orifice row advantageously is in the range of zero point one (0.1) to two point eight (2.8) grams per minute The fibers attenuated from the orifice rows of each die source advantageously can have a diameter in the range of zero point three (0.3) to twenty (20) micrometers in diameter and the polymer material can be but is not limited to polyester having a density of approximately one point four (1.4) grams per cubic centimeter, a polypropylene having a density of approximately zero point nine (0.9) grams per cubic centimeter or a nylon having a density of approximately one point one four (1.14) grams per cubic centimeter. In accordance with one feature of the present invention, the emitted fibers from each row of spaced orifices are attenuated by pairs of oppositely directed fluid air stream advantageously at a rate of up to six hundred (600) feet per second, the air streams advantageously being heated to a temperature of approximately seven hundred (700 F) degrees Fahrenheit. These oppositely directed air streams are so angularly directed as to include an angle between opposed streams in excess of approximately ninety-five (95) degrees, desirably within an approximate range of ninety-five (95) to one hundred twenty (120) degrees and advantageously at one hundred eight (108) degrees plus or minus two (2) degrees. This angular direction of the opposed attenuating fluid streams serves to provide a turbulent fiber flow, increasing the rate of fiber attenuation. In accordance with still another feature of the present invention, a cooling treatment of the attenuated fibers with cool air is applied to either side of each of the layer rows of fibers at the fiber attenuation location in order to enhance crystallization before the fibers are collected in face-to-face layered form on a collector, such as a revolving drum or endless belt. This treatment serves to avoid bonding between adjacent layer faces and to reduce fiber bonding within each layer so as to increase filter media bulk with accompanying increased dust holding capacity and overall efficiency.

In accordance with still another feature of the present invention, a unique and novel filter media is produced by the apparatus and method described herein, such unique filter media includes a layered fibrous fluid filter media web of melt blown fibrous material comprising at least two or more freely separable face to face melt blown layers of fibrous filter media free of layer bonding with the fibers in each layer having a minimum bonded relation to provide a fibrous filter media of maximized bulk with accompanying increased dust holding capacity and increased overall efficiency. The fibers of such novel filter media advantageously can be in the range of zero point three (0.3) to twenty (20) micrometers in diameter and can be of polymeric nature of either a polyester with a density of approximately one point four (1.4) grams per cubic centimeter or a polypropylene with a density of approximately zero point nine (0.9) grams per cubic centimeter or a nylon with a density of approximately one point one four (1.14) grams per cubic centimeter.

Claims

1. A process for forming a layered web of fibrous filter media wherein adjacently facing layers of fibrous filter media are distinctly separate from each other comprising: sequentially feeding filter media fibers in heated form from heated melt blown die source orifices toward a spaced collector source to be layered as at least two separate and distinct layers of fibrous filter media on said collector source with one fibrous filter media layer being on top of the other in faced relation and treating the fibers of said facing layers of fibrous filter media between said die source and said collector source to enhance crystallization to avoid bonding between adjacent media layer faces and to minimize fiber bonding within each of said layers so as to increase said layered web of fibrous filter media in bulk with increased dust holding capacity and overall filtering efficiency.

2. The process for forming said layered web of fibrous filter media of Claim 1 wherein said layers are formed from at least two spaced die head sources disposed in a common die body source.

3. The process for forming said layered web of fibrous filter media of Claim 2 wherein said fibers of each of said layers are treated with a cooling fluid intermediate said spaced die head sources and before

deposit on said collector source to enhance crystallization and to so avoid facing layer bonding and to minimize possible bonding within each layer.

4. The process for forming said layered web of filter media of Claim 3, wherein said fiber treating cooling fluid is cool air.

5. The process for forming a layered web of fibrous filter media of Claim 1, wherein said filter media fibers are of a polymer material which when heated at the die has a viscosity in the range of ten (10) to three hundred (300) poise.

6. The process for forming a layered web of fibrous filter media of Claim 1, wherein the fibers of said facing layers are attenuated by fluid streams cooperatively positioned at opposed angles to said die source orifices with said opposed angles determining an included angle within an approximate range of ninety-five degrees (95 degrees) to one hundred twenty (120 degrees) so as to provide a high velocity, turbulent, pulse-like, sinusoidal fiber flow increasing the rate of fiber attenuation.

7. The process for forming a layered web of fibrous filter media of Claim 6, wherein said attenuating fluid streams are air heated up to a temperature of approximately seven hundred (700F) degrees Fahrenheit.

8. The process for forming a layered web of fibrous filter media of Claim 1, wherein said heated melt blown fibers are attenuated through spaced rows of die orifices, the number of attenuated fibers in each row being in the range of at least approximately ten (10) to at least fifty (50) per inch.

9. The process for forming a layered web of fibrous filter media of Claim 8, wherein the number of attenuated fibers in each row advantageously is at least approximately thirty (30) per inch.

10. A process for forming a layered web of fibrous filter media wherein adjacently facing layers of fibrous filter media are distinctly separate from each other comprising; sequentially feeding polymer filter media fibers in heated form with a viscosity in the range of ten (10) to three hundred (300) poise from several preselectively spaced heated melt blown die sources in fiber form including several spaced layer rows of fibers spaced orifices with each row advantageously having at least approximately thirty (30) fibers per inch with an output per fiber from the die source being in the range of zero point one (0.1) to two point eight (2.8) grams per minute and with the several heated melt blown die sources being within a common die body source; attenuating said polymer fibers as they emanate from said die source as a row of spaced fibers to be directed as a layer to a spaced moving collector by pairs of oppositely angularly directed air streams advantageously at a rate up to six hundred (600) cubic feet per second and advantageously heated up to a temperature of approximately seven hundred (700 F) degrees Fahrenheit, said opposed air streams being directed angularly in opposition to each other to include an angle advantageously of approximately one hundred and eight (108) degrees so as to provide a turbulent, pulse-like, sinusoidal fiber flow increasing the rate of fiber attenuation producing fibers within a range of zero point three (0.3) to twenty (20) micrometers (um); and, cooling either side of each of said layer rows of attenuated polymer fibers with cooled air before deposit on said moving collector so as to enhance crystallization and to avoid bonding between adjacent layer faces and to reduce fiber bonding within each layer so as to increase filter media bulk with accompanying increased dust holding capacity and overall efficiency.

11. Die apparatus for forming a layered web of fibrous filter media with the layers thereof distinctly separate from each other comprising: a unitary die body formed from a preselected heat conductive material, said die body having formed therein at least two preselectively spaced fluid material flow-through passages, each fluid material flow-through passage having a fluid material receiving inlet and a fluid material dispensing outlet adapted to dispense a row of layer forming fibers therefrom with the dispensed fiber layers to be collected in stacked, facing relation, said die body further having formed therein at least two pairs each of oppositely disposed fluid attenuating flow-through passages, each passage having a fluid attenuating inlet and fluid attenuating outlet with the oppositely disposed fluid attenuating outlets of each pair of fluid attenuating flow-through passages being disposed at preselectively opposed angles to define a preselected included angle in excess of approximately ninety-five (95) degrees so that said fluid attenuating outlets are so angularly positioned opposite each other and relative each of said fluid material outlets to provide a turbulent, pulse-like, sinusoidal attenuated fibrous flow from each of said fluid material outlets to thus increase the rate of fibrous layer attenuation; heating means cooperative with said unitary die body whereby heat is conducted to said fluid material flow-through passages and said fluid attenuating flow-through passages; and insulating means cooperative with the outer face of said heating means to insulate the same at preselected locations.

12. The die apparatus of Claim 11, said unitary die body being formed with a recessed section adjacent each

of said fluid material and said opposed pair of fluid attenuating outlets to include a removable fluid material nose outlet section having a passage therein communicably connectable as part of said flow-through fluid material outlets in said die body and a fluid lip section conforming with and communicably connectable as part of said opposed flow-through fluid attenuating passages.

13. The die apparatus of Claim 11, and fluid treating passages cooperative with said fluid outlets of said die body to treat attenuated fibrous material so as to enhance crystallization and to avoid subsequent bonding between collected adjacent facing fibrous layers and to reduce bonding within each layer thus increasing layered fibrous filter media web bulk with increased filter capacity and overall efficiency.

14. The die apparatus of Claim 11, said preselected included angle between said opposed fluid attenuating outlets being in the approximate range of ninety-five (95) to one hundred twenty (120) degrees.

15. The die apparatus of Claim 11, said heat conductive unitary die body being of a nickel-chromium alloyed steel.

16. The die apparatus of Claim 11, said heating means being a cast aluminum alloy-electric coil heater.

17. The die apparatus of Claim 11, said insulating means being of a preselected, non-conductive, inorganic matter.

18. The die apparatus of Claim 11, said insulating means being of a non-conductive ceramic material.

19. The die apparatus of Claim 11, said heating means being a heating jacket cooperatively surrounding said unitary die body to conduct heat to said fluid material and fluid attenuating passages and said insulating means being an insulating jacket cooperatively surrounding the outer face of said heating jacket.

20. The die apparatus of Claim 12, said fluid material nose outlet section including a passageway communicably connected as part of said fluid material outlet in said die body and including an orifice plate having an approximate range of ten (10) to fifty (50) spaced fiber dispensing apertures per inch of orifice plate.

21. The die apparatus of Claim 20, said orifice plate having a row of spaced dispensing apertures advantageously amounting to thirty (30) spaced apertures per inch.

22. The die apparatus of Claim 12 said fluid material nose outlet and said fluid lip sections being of a nickel-chromium alloyed steel.

23. Die apparatus for forming a layered web of fibrous filter media with the layers thereof distinctly separate from each other comprising: a unitary die body formed from a heat conductive nickel-chromium alloyed steel, said die body having drill formed therein several fluid material flow through passages, each fluid material flow-through passage having a fluid material receiving inlet to be connected to a fluid material supply source externally of said die body and a fluid material dispensing outlet, said die body further having drill formed therein at least two pair of oppositely disposed fluid attenuating flow through passages, each pair of oppositely disposed attenuating passages having a fluid attenuating inlet and fluid attenuating outlet with the oppositely disposed fluid attenuating flow-through passages being angularly disposed to define a preselected included angle of approximately one hundred and eight (108) degrees plus or minus two (2) degrees so that said fluid attenuating cutlets of said opposed fluid attenuating passages are so angularly positioned on opposite sides of each of said fluid material outlets so as to provide a turbulent, pulse-like, sinusoidal attenuating fibrous flow from each of said fluid material outlets to thus increase the rate of fibrous layer attenuation, said unitary nickel chromium steel die body further having stepped recessed portions to snugly and removably receive the base portions of nickel and chromium alloyed steel nose sections, said nose sections having apex portions with a substantially triangularly shaped cross-section, said nose sections including fluid material outlet passageways communicating with said fluid material passages in said die body to form a continuing part thereof, said nose sections each having a longitudinally extending orifice plate therein adjacent the apex portion of said nose section to be in communication with said fluid material passageways to receive fluid material therefrom, said orifice plate including at least one row of spaced fibrous fluid emitting apertures therein, said spaced apertures numbering approximately thirty (30) per inch, each being preselectively sized and geometrically shaped to determine the size and cross-sectional shape of the layered fibrous material passed therethrough, said recessed portions of said die body further removably receiving longitudinally extending opposed mirror-image spaced lip sections to be spaced from and contoured to cooperate with the side flanks of said apex portion of said nose section to define fluid attenuating passageways which form part of and angularly continue the fluid attenuating passages in said die body; an aluminum alloyed, electric coil heating jacket cooperatively surround-

ing said unitary die to conduct heat to said passages therein; a ceramic insulating jacket cooperatively surrounding the outer face of said heating jacket; and apertured fluid treating conduits cooperative with said fluid outlets of said nose and lip sections to treat emitted layered fibrous material to enhance crystallization and to avoid subsequent bonding of collected adjacent facing fibrous layers and to reduce bonding of individual fibers within each layer to increase media bulk and filtering efficiency.

24. A layered fibrous fluid filter media web of melt blown fibrous material comprising: at least two freely separable face-to-face melt blown layers of fibrous filter media free of layer bonding with the fibers in each layer having a minimum bonded relation providing a layered fibrous filter media of increased filter media bulk with accompanying increased dust holding capacity and overall efficiency.

25. The layered fibrous fluid filter media web of Claim 24, wherein said melt blown fibrous material has fibers with zero point three (0.3) to twenty (20) micrometers in diameter.

26. The layered fibrous fluid filter media of Claim 24 wherein said melt blown fibrous material has polymeric fibers.

27. The layered fibrous fluid filter media of Claim 26 wherein said polymeric fibers are a polyester having a density of approximately one point four (1.4) grams per cubic centimeter.

28. The layered fibrous filter media of Claim 26 wherein said polymeric fibers ar a polypropylene having a density of approximately zero point nine (0.9) grams per cubic centimeter.

29. The layered fibrous filter media of Claim 26 wherein said polymeric fibers are a nylon having a density of approximately one point one four (1.14) grams per cubic centimeter.

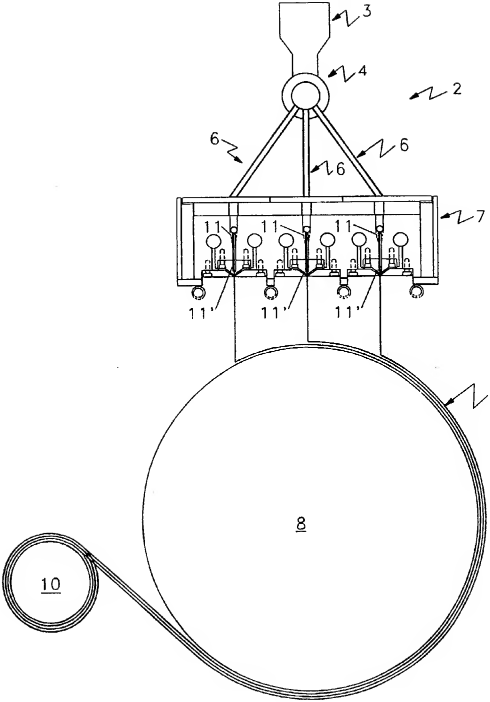

FIG. 1

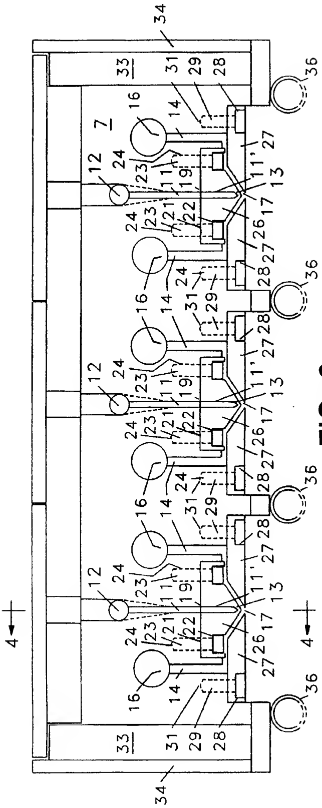

FIG. 2

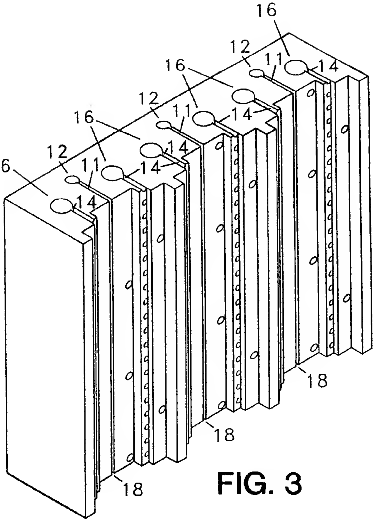
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FIG. 3

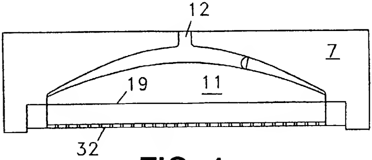
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FIG. 4

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Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for all designations*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations*

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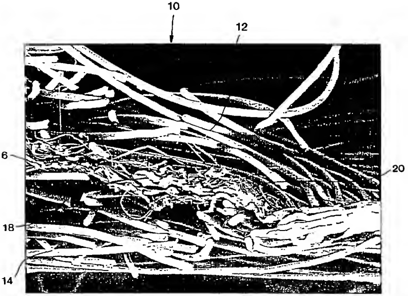
(54) Title: NONWOVEN FABRIC LAMINATE WITH MELTBLOWN WEB HAVING A GRADIENT FIBER SIZE STRUCTURE



(57) Abstract: A nonwoven fabric laminate having a meltblown layer positioned between two spunbond nonwoven layers. The meltblown layer having a gradient fiber size structure across a thickness thereof with at least one layer of coarse meltblown fibers. In one embodiment, the gradient fiber size structure has at least two layers of meltblown fibers, for example at least one layer of fine meltblown fibers and at least one layer of coarse meltblown fibers, having a mean fiber diameter difference of at least 4.0 microns

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NONWOVEN FABRIC LAMINATE WITH MELTBLOWN WEB HAVING A GRADIENT FIBER SIZE STRUCTURE

BACKGROUND OF THE INVENTION

Nonwoven fabric laminates are useful for a wide variety of applications. Such nonwoven fabric laminates are useful for wipers, towels, industrial garments, medical garments, medical drapes and similar articles. Disposable fabric laminates are used in hospital operating rooms for drapes, gowns, towels, footcovers, sterile wraps and the like. These surgical fabric laminates are generally spunbond/meltblown/spunbond (SMS) laminates having nonwoven outer layers of spunbond polypropylene and an inner layer of meltblown polypropylene. The outer spunbond layers provide strength and durability to the SMS laminate. The inner meltblown layer inhibits the flow or strikethrough of fluids through the SMS laminate yet allows for breathability.

However, there remains a need for a meltblown layer for use in the SMS laminate which provides an "open" structure with high breathability and a "closed" structure with desired barrier properties, high opacity and/or better coverage.

SUMMARY OF THE INVENTION

In response to the discussed difficulties and problems encountered in the prior art, a fabric laminate having a meltblown web with a gradient fiber size structure disposed between two nonwoven layers, has been discovered. Desirably, each nonwoven layer is a spunbond nonwoven layer of substantially continuous fibers. The meltblown web includes at least one layer of coarse meltblown fibers and may include at least one layer of fine meltblown fibers, which form the gradient fiber size structure across a thickness of the meltblown layer.

The SMS fabric laminate of this invention has good strength, flexibility and drape and may be formed into various articles or garments such as surgical gowns, surgical drapes and the like. The barrier properties of the SMS fabric laminate make it particularly suitable for medical applications, such as surgical gowns, but the SMS fabric laminate is also useful for any other application where barrier properties are desirable.

The nonwoven spunbond layers are produced using conventional spunbonding processes and have substantially continuous thermoplastic spunbond fibers. In accordance with one embodiment of this invention, the meltblown web has at least two layers of meltblown fibers, with at least one of the layers of meltblown fibers having a plurality of coarse meltblown fibers, which provide the desired breathability to the meltblown web. The meltblown web may also include at least one layer of fine meltblown fibers, which provide the desired barrier properties to the meltblown web.

Particularly desirable meltblown fibers for the layers of the meltblown web include monocomponent fibers, for example polypropylene fibers. In addition to polypropylene fibers, the present invention can be carried out using any thermoplastic polymer resin that can be meltblown to form a meltblown web. In one embodiment of this invention, the layers of the meltblown web may include bicomponent fibers.

The meltblown web according to one embodiment of this invention may be formed by bonding at least two independently formed meltblown layers together. The meltblown layers are bonded surface-to-surface using conventional bonding means. The meltblown web is then bonded between the two nonwoven spunbond layers to produce the SMS fabric laminate.

The gradient fiber size structure and other physical properties of the meltblown web can be adjusted by manipulation of the various process parameters of the meltblowing process. The following parameters may be adjusted and/or varied in order to change the physical properties or characteristics of the resulting meltblown web: polymer meltflow rate; polymer melt temperature (°F); forming height (inches); primary air pressure (psi); and vacuum under forming belt or underwire vacuum (inches of water).

Alternatively, the meltblown web layers may be formed in-line with the SMS fabric laminate. In this embodiment, the SMS fabric laminate is produced using a forming apparatus having at least three stations, a spunbonding station, a meltblowing station, and a second spunbonding station. Desirably, a plurality of meltblowing stations are utilized to form a meltblown web having at least two layers of meltblown fibers, for example at least one layer of coarse meltblown fibers and at least one layer of fine meltblown fibers, which form a gradient fiber size structure. A meltblown web including at least two layers is

deposited directly on the first nonwoven spunbond layer during the in-line process. A second nonwoven spunbond layer is subsequently deposited directly on an opposite side of the meltblown web to produce the SMS fabric laminate.

With the foregoing in mind, it is a feature and advantage of the invention to provide a meltblown web for use in a SMS fabric laminate having a gradient fiber size structure across a thickness thereof.

It is also a feature and advantage of the invention to provide a SMS fabric laminate having high breathability and desired barrier properties, including high opacity and coverage.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 shows a Scanning Electronmicrograph (SEM) image of a cross-section of a SMS fabric laminate having a meltblown web of coarse and fine fibers, in accordance with one embodiment of this invention;

Fig. 2 is a schematic view of a forming apparatus used to produce a meltblown layer, in accordance with one embodiment of this invention; and

Fig. 3 is a schematic view of a forming apparatus used to produce a SMS fabric laminate having a meltblown web with a gradient fiber size structure, according to one embodiment of this invention.

DEFINITIONS

As used herein, the term "coarse meltblown fibers" refers to meltblown fibers produced by a meltblowing process having an average diameter of at least about 5.0 microns, desirably about 5.0 microns to about 30 microns. A coarse fiber meltblown web has an "open" web structure.

As used herein, the term "fine meltblown fibers" refers to meltblown fibers produced by a meltblowing process having an average diameter less than about 5.0 microns, desirably about 0.1 micron to about 4.0 microns. A fine fiber meltblown web has a "closed" web structure.

The term "layer" when used in the singular refers to a layer of a multilayer web or fabric structure.

The term "meltblown fibers" means fibers formed by extruding a molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten threads or filaments into converging high velocity gas (e.g., air) streams which attenuate the filaments of molten thermoplastic material to reduce their diameter, which may be to microfiber diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly dispersed meltblown fibers. Such a process is disclosed for example, in U.S. Patent 3,849,241 to Butin and in U.S. Patent 6,001,303 to Haynes, et al. Meltblown fibers are microfibers which may be continuous or discontinuous and are generally self bonding when deposited onto a collecting surface.

The term "monocomponent fiber" refers to a fiber formed from one or more extruders using only one polymer. This is not meant to exclude fibers formed from one polymer to which small amounts of additives have been added for color, anti-static properties, lubrication, hydrophilicity, etc. These additives, e.g., titanium dioxide for color, are generally present in an amount less than 5 weight percent and more typically about 2 weight percent.

The term "nonwoven fabric or web" means a web having a structure of individual fibers or threads which are interlaid, but not in a regular or identifiable manner as in a knitted fabric. Nonwoven fabrics or webs have been formed from many processes such as, for example, meltblowing processes, spunbonding processes, air laying processes, and bonded carded web processes. The basis weight of nonwoven fabrics is usually expressed in ounces of material per square yard (osy) or grams per square meter (gsm) and the fiber diameters are usually expressed in microns. (Note that to convert from osy to gsm, multiply osy by 33.91.) The terms include nonwoven fabrics or webs having multiple layers.

The term "polymer" includes, but is not limited to, homopolymers, copolymers, such as for example, block, graft, random and alternating copolymers, terpolymers, etc. and blends and modifications thereof. Further, unless otherwise specifically limited, the term "polymer" shall include all possible geometrical configurations of the material. These configurations include, but are not limited to isotactic, syndiotactic and atactic symmetries.

The term "spunbond fibers" refers to small diameter fibers which are formed by extruding molten thermoplastic material as filaments from a plurality of fine capillaries of a spinnerette having a circular or other configuration, with the diameter of the extruded filaments then being rapidly reduced as by, for example, in U.S. Patent 4,340,563 to Appel et al., and U.S. Patent 3,692,618 to Dorschner et al., U.S. Patent 3,802,817 to Matsuki et al., U.S. Patents 3,338,992 and 3,341,394 to Kinney, U.S. Patent 3,502,763 to Hartman, U.S. Patent 3,502,538 to Petersen, and U.S. Patent 3,542,615 to Dobo et al., each of which is incorporated herein in its entirety by reference. Spunbond fibers are quenched and generally not tacky when they are deposited onto a collecting surface. Spunbond fibers are generally continuous and often have average diameters larger than about 7 microns, more particularly, between about 10 and 30 microns.

These terms may be defined with additional language in the remaining portions of the specification.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

As shown in Fig. 1, a SMS fabric laminate 10, in accordance with one embodiment of this invention, includes a first spunbond nonwoven layer 12, a second spunbond nonwoven layer 14 and a meltblown web 16 disposed between the first spunbond nonwoven layer 12 and the second spunbond nonwoven layer 14. In accordance with one embodiment of this invention, the meltblown web 16 has at least one layer of coarse meltblown fibers 18 and may have at least one layer of fine meltblown fibers 20, which form a gradient fiber size structure across a thickness of the meltblown web 16. Although reference is made throughout this specification and in the claims to a SMS fabric laminate, it is apparent to one skilled in the art that the meltblown web 16 may be disposed between suitable nonwoven layers which are not spunbond nonwoven layers.

Desirably, the gradient fiber size structure is formed having adjacent layers of meltblown fibers with a mean fiber diameter difference of at least 4.0 microns. For example, a layer of fine meltblown fibers 20 having a mean fiber diameter of about 2.0 microns is bonded to a layer of course meltblown fibers 18 having a mean fiber diameter of about 14.5 microns to form the meltblown web 16. Desirably, the overall basis weight of the

SMS fabric laminate 10 is about 16 grams per square meter (gsm) to about 275 gsm, more desirably about 33 gsm to about 136 gsm, still more desirably about 33 gsm to about 68 gsm.

The SMS fabric laminate 10 of this invention has good strength, flexibility and drape and may be formed into various articles or garments such as surgical gowns, surgical drapes and the like. The barrier properties of the SMS fabric laminate 10 make it particularly suitable for medical applications, such as surgical gowns, but the SMS fabric laminate 10 is also useful for any other application where barrier properties are desirable.

The first nonwoven spunbond layer 12 and the second nonwoven spunbond layer 14 may be produced using spunbonding processes well known to those having ordinary skill in the art and have substantially continuous thermoplastic spunbond fibers. Desirably, the first nonwoven spunbond layer 12 and the second nonwoven spunbond layer 14 each has a basis weight of about 10 grams per square meter (gsm) to about 100 gsm, more desirably about 12 gsm to about 24 gsm. It is also desirable that the spunbond fibers have an average diameter of about 10 microns to about 30 microns, more desirably about 15 microns to about 25 microns.

A wide variety of thermoplastic polymers may be used to construct the the first nonwoven spunbond layer 12 and the second nonwoven spunbond layer 14 including, but not limited to polyamides, polyesters, polyolefins, copolymers of ethylene and propylene, copolymers of ethylene or propylene with a C_4-C_{20} alpha-olefin, terpolymers of ethylene with propylene and a C_4-C_{20} alpha-olefin, ethylene vinyl acetate copolymers, propylene vinyl acetate copolymers, styrene-poly(ethylene-alpha-olefin) elastomers, polyurethanes, A-B block copolymers where A is formed of poly(vinyl arene) moieties such as polystyrene and B is an elastomeric midblock such as a conjugated diene or lower alkene, polyethers, polyether esters, polyacrylates, ethylene alkyl acrylates, polyisobutylene, polybutadiene, isobutylene-isoprene copolymers, and combinations of any of the foregoing. Polyolefins are desirable. Polyethylene and polypropylene homopolymers and copolymers are most desirable.

Desirably, the meltblown web 16 has a basis weight of about 5 gsm to about 34 gsm, more desirably about 9 gsm to about 15 gsm. In accordance with one embodiment of this invention, the meltblown web 16 includes at least two layers of meltblown fibers 17

and 19, as shown in Fig. 1. At least one of the layers of meltblown fibers 17, 19 has a plurality of coarse meltblown fibers 18. The coarse meltblown fibers 18 have an average diameter of at least about 5.0 microns, desirably about 5.0 microns to about 30 microns. The coarse meltblown fibers 18 provide an "open" web structure, which provides the desired breathability to the meltblown web 16.

The meltblown web 16 may also have at least one layer of fine meltblown fibers 20, as shown in Fig. 1. The fine meltblown fibers 20 have an average diameter less than about 5.0 microns, desirably about 0.1 micron to about 4.0 microns. The fine meltblown fibers 20 provide a "closed" web structure, which provides the desired barrier properties, including high opacity and coverage, to the meltblown web 16.

The meltblown web 16 may be constructed of the same or similar thermoplastic polymers used to construct the first nonwoven spunbond layer 12 and the second nonwoven spunbond layer 14, as discussed above. Particularly desirable meltblown fibers for the layers of the meltblown web 16 include monocomponent fibers, for example polypropylene fibers. In addition to polypropylene fibers, the present invention can be carried out using any thermoplastic polymer resin that can be meltblown to form a meltblown web.

The meltblown web 16 according to one embodiment of this invention may be formed by bonding at least two meltblown layers of meltblown fibers together. The meltblown layers are bonded surface-to-surface using conventional bonding means, including, but not limited to thermal bonding, ultrasonic bonding and adhesive bonding. In this embodiment, the meltblown layers are independently formed using a forming apparatus 30, as shown in Fig. 2, and subsequently bonded together.

The meltblown web 16 may also be formed with the first nonwoven spunbond layer 12 and the second nonwoven spunbond layer 14 as a continuous in-line process, as discussed below. The forming apparatus 30 includes a meltblown station 32 having a die 33 which is used to form meltblown fibers, for example coarse meltblown fibers 18 and fine meltblown fibers 20 (not shown). The distance between the die 33 and a forming belt 34 is designated as the "forming height." Within the meltblown station 32, a thermoplastic polymer resin, for example a polypropylene resin, is heated to a melting temperature of the

thermoplastic polymer resin to form a polymer melt. As the polymer melt exits the die 33, a high pressure fluid, usually air, attenuates and spreads a stream of the polymer melt to form the coarse meltblown fibers 18. The pressure at which the air exits the die 33 is designated the "primary air pressure." The coarse meltblown fibers 18 are randomly deposited on the moving forming belt 34 to form a coarse fiber meltblown layer 19, as shown in Fig. 2.

As the coarse meltblown fibers 18 are deposited on the forming belt 34, a vacuum unit 36, positioned under the forming belt 34, draws the coarse meltblown fibers 18 towards the forming belt 34 during the formation of the coarse fiber meltblown layer 19. Desirably, the vacuum unit 36 has at least two, more desirably three independently controllable vacuum units, as shown in Fig. 2. The independently controllable vacuum units are placed along a length of the forming belt 34 to allow different vacuum settings as the coarse fiber meltblown layer 19 moves along the forming belt 34. A fine fiber meltblown web may be formed using the same or similar forming apparatus 30.

Independently formed meltblown layers are layered together or bonded together using conventional bonding techniques, for example thermal bonding and ultrasonic bonding, to form the meltblown web 16. The meltblown web 16 is then bonded between the first nonwoven spunbond layer 12 and the second nonwoven spunbond layer 14 to produce the SMS fabric laminate 10, in accordance with one embodiment of this invention.

The gradient fiber size structure and other physical properties of the meltblown web 16 can be adjusted by manipulation of the various process parameters of the meltblowing process. The following parameters may be adjusted and/or varied in order to change the physical properties or characteristics of the resulting meltblown web 16: type of polymer; polymer melt temperature (°F); forming height (inches); primary air pressure (psi); and vacuum under forming belt or underwire vacuum (inches of water).

As an alternative to bonding independently formed meltblown layers to form the meltblown web 16, the meltblown web 16 may be formed in-line with the SMS fabric laminate. In accordance with one embodiment of this invention, the SMS fabric laminate 10 is produced using a forming apparatus 40, as shown in Fig. 3. The forming apparatus 40 has at least three stations, a spunbonding station 42, a meltblowing station 44, and a second spunbonding station 47. Desirably, a plurality of meltblowing stations, for example

meltblowing station 44, a second meltblowing station 45, and a third meltblowing station 46, are utilized to form a meltblown web 16 having a gradient fiber size structure formed by a plurality of layers of meltblown fibers.

The spunbond station 42 produces continuous spunbond fibers 11 which are deposited on a forming belt 50 to produce the first nonwoven spunbond layer 12. The spunbond station 42 and spunbond station 47 are conventional extruders with spinnerets which form the first spunbond nonwoven layer 12 and the second spunbond nonwoven layer 14, respectively, by methods well known to those having ordinary skill in the art.

The meltblowing station 44 includes a die 48 which is used to form meltblown fibers, for example coarse meltblown fibers 18. Within the meltblowing station 44, a thermoplastic polymer resin, for example a polypropylene resin, is heated to a melting temperature of the thermoplastic polymer resin to form a polymer melt. As the polymer melt exits the die 48, a high pressure fluid, usually air, attenuates and spreads a stream of the polymer melt to form the coarse meltblown fibers 18. The coarse meltblown fibers 18 are randomly deposited on the first nonwoven spunbond layer 12 moving on the forming belt 50 to form a layer 21 of coarse meltblown fibers 18.

The second meltblowing station 45 includes a die 49 which is used to form meltblown fibers, for example fine meltblown fibers 20. Within the second meltblowing station 45, a thermoplastic polymer resin, for example a polypropylene resin, is heated to a melting temperature of the thermoplastic polymer resin to form a polymer melt. As the polymer melt exits the die 49, a high pressure fluid, usually air, attenuates and spreads a stream of the polymer melt to form the fine meltblown fibers 20. The fine meltblown fibers 20 are randomly deposited on the layer 21 of coarse meltblown fibers 18 moving on the forming belt 50. The fine meltblown fibers 20 form a layer 23.

In accordance with one embodiment of this invention, the third meltblowing station 46 is aligned along the forming belt 50 to deposit meltblown fibers, for example course meltblown fibers 18, on the layer 23 to form a layer 25 of coarse meltblown fibers 18. The layers 21, 23 and 25 of meltblown fibers deposited on the first nonwoven spunbond layer 12 produce the meltblown web 16 with the gradient fiber size structure. Each

meltblowing station 44, 45, 46, can be used to produce course meltblown fibers 18 or fine meltblown fibers 20, as desired.

After the meltblown web 16 is formed on the first nonwoven spunbond layer 12, the spunbond station 47 produces continuous spunbond fibers 13 which are deposited on the meltblown web 16 to produce the second nonwoven spunbond layer 14. The resulting SMS fabric laminate 10 is then fed through bonding rolls 52 and 54. The bonding rolls 52 and 54 are heated to a softening temperature of a polymer used to form at least one of the layers of the SMS fabric laminate 10. As the SMS fabric laminate 10 passes between the heated bonding rolls 52 and 54, the layers are compressed and thermally bonded together. Other conventional bonding means may be used to bond the layers of the SMS fabric laminate 10.

EXAMPLE 1

Six meltblown layers were produced using the forming apparatus shown in Fig. 2, including one fine fiber meltblown layer (designated MB Roll 01) and five coarse fiber meltblown layers (designated consecutively MB Roll 02-06). The process parameters, including the type of polymer, polymer melt temperature, forming height, primary air pressure, and/or underwire vacuum, were varied in accordance with Table 1. Desirably, the forming vacuum control is maintained at 100% output to ensure full process capacity. MB Roll 01-05 layers were produced using a medium melt flow rate polypropylene resin supplied under the trade name Montell® PF-015. MB Roll 06 layer was produced using a low melt flow rate (400 MFR) polypropylene resin, without peroxide, supplied by the Exxon Chemical Company under the trade name Exxon® 3505.

TABLE 1

MB Roll	Fiber Type	Polymer	Forming Height (inches)	Melt Temp. (°F)	Primary Air Pressure (psi)	Underwire Vacuum 1, 2, 3 (inch of water)	Forming Vacuum Control (% Output)
01	Fine	PF-015	8	437	16	0,16,20	100
02	Coarse	PF-015	8	437	3.8	0,16,20	100
03	Coarse	PF-015	8	396	3.5	0,16,20	100
04	Coarse	PF-015	10	402	4.0	0,16,20	100
05	Coarse	PF-015	10	390	3.9	0,5,4	100
06	Coarse	3505	10	390	3.9	0,4,5	100

The fine fiber meltblown layer (MB Roll 01) and three coarse fiber meltblown layers (MB Roll 03, 05, and 06), produced using the forming apparatus shown in Fig. 2, were tested using an Image Analysis of Meltblown Fiber Diameter test. Each meltblown layer was tested for Count-Based Mean Diameter, Volume-Based Mean Diameter, and Anisotropy. Results of this test are displayed in Table 2. Two test samples, designated "A" and "B," were conducted for each meltblown layer.

Test Procedures

Count-Based Mean Diameter

The count-based mean diameter is the average fiber diameter based on all fiber diameter measurements taken. For each test sample, 300 to 500 fiber diameter measurements were taken.

Volume-Based Mean Diameter

The volume-based mean diameter is also an average fiber diameter based on all fiber diameter measurements taken. However, the volume-based mean diameter is based on the volume of the fibers measured. The volume is calculated for each test sample and is based on a cylindrical model using the following equation:

$$V=\pi A^2/2P;$$

where A is the cross-sectional area of the test sample and P is the perimeter of the test sample. Fibers with a larger volume will carry a heavier weighting toward the overall average. For each test sample, 300 to 500 measurements were taken.

Anisotropy

The Anisotropy describes the orientation of the fibers. It is a dimensionless measurement and is defined by the following equation:

Anisotropy = horizontal area/vertical intercept.

It is a field measurement and is therefore measured once for each image. A value of less than 1.0 indicates a machine direction fiber orientation while a value of greater than 1.0 indicates a cross-machine direction fiber orientation. A value of 1.0 represents random fiber orientation.

TABLE 2

	Count-Based Diameter		Volume-Based Diameter		
MB Roll	Mean (microns)	STD DEV (microns)	Mean (microns)	STD DEV (microns)	Anisotropy
01A	1.93	1.20	3.76	2.32	1.037
01B	2.05	1.16	3.44	1.53	1.237
03A	6.43	4.05	12.2	6.36	1.139
03B	7.08	4.10	11.90	5.20	1.004
05A	14.60	9.10	26.50	11.90	0.973
05B	14.00	7.30	21.90	9.36	1.088
06A	7.01	4.58	14.50	8.46	1.294
06B	7.12	4.45	13.10	6.25	1.491

EXAMPLE 2

Selected meltblown layers from Example 1 were layered together to form five meltblown webs, as shown in Table 3. For example, a MB Roll 01 layer was layered or positioned between two MB Roll 03 layers to form one meltblown web sample. The five meltblown webs were tested for basis weight, air permeability, cup crush load, cup crush

energy and opacity using standard testing procedures as outlined below. Results of these tests are displayed in Table 3.

Test Procedures

Basis Weight

The basis weight of a nonwoven fabric is determined by measuring the mass of a nonwoven fabric sample, and dividing it by the area covered by the sample. The basis weight was reported in grams per square meter (gsm).

Air Permeability

This test determines the airflow rate through a sample for a set area size and pressure. The higher the airflow rate per a given area and pressure, the more open the fabric is, thus allowing more fluid to pass through the fabric. Air permeability is determined using a pressure of 125 Pa (0.5 inch water column) and is reported in cubic feet per minute per square foot. The air permeability data reported herein can be obtained using a TEXTEST FX 3300 air permeability tester.

Cup Crush

The softness of a nonwoven fabric may be measured according to the "cup crush" test. The cup crush test evaluates fabric stiffness by measuring the peak load or "cup crush" required for a 4.5 cm diameter hemispherically shaped foot to crush a 25 cm by 25 cm piece of fabric shaped into an approximately 6.5 cm diameter by 6.5 cm tall inverted cup while the cup shaped fabric is surrounded by an approximately 6.5 cm diameter cylinder to maintain a uniform deformation of the cup shaped fabric. An average of 10 readings is used. The foot and the cup are aligned to avoid contact between the cup walls and the foot which could affect the readings. The peak load is measured while the foot is descending at a rate of 40.6 cm/minute and is measured in grams. The cup crush test also yields a value for the total energy required to crush a sample (the "cup crush energy") which is the energy from the start of the test to the peak load point, i.e. the area under the curve formed by the load in grams on one axis and the distance the foot travels in millimeters on the other. Cup crush energy is therefore reported in g-mm. Lower cup crush values indicate a softer fabric. A suitable device for measuring cup crush is a Sintech Tensile Tester and 500g load cell using

TESTWORKS Software all of which are available from Sintech, Inc. of Research Triangle Park, NC.

Opacity

This test determines the percent opacity of a sample. The higher the opacity, the more closed the fabric is, thus providing better barrier properties, coverage and visual aesthetics. The opacity data reported herein can be obtained using a HunterLab Color Difference Meter, Model DP 9000. The sample is placed on a specimen port and a percent opacity of the sample is determined. The test is based on a percentage of light which passes through the sample. For example, when no light passes through the sample, the sample will have 100% opacity. Conversely, 0% opacity corresponds to a transparent sample.

TABLE 3

Meltblown Layer Sample	Basis Weight (gsm)	Air Permeability (cfm)	Cup Crush Load (gm)	Cup Crush Energy (gm-mm)	Opacity (%)
MB Roll #03 MB Roll #01 MB Roll #03	0.42	176	21	243	51
MB Roll #05 MB Roll #01 MB Roll #05	0.42	212	24	168	42
MB Roll #01 MB Roll #06	0.28	165	21	148	48
MB Roll #01 MB Roll #03	0.28	201	23	106	42
MB Roll #01 MB Roll #05	0.28	227	17	109	39

While the invention has been described in detail with respect to specific embodiments thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing, may readily conceive of alterations to, variations of and equivalents to these embodiments. Accordingly, the scope of the present invention should be assessed as that of the appended claims and any equivalents thereto.

WHAT IS CLAIMED IS:

1. A nonwoven fabric laminate, comprising:

a first nonwoven layer;

a second nonwoven layer; and

a meltblown web positioned between the first nonwoven layer and the second nonwoven layer, the meltblown web having a gradient fiber size structure wherein adjacent layers of the meltblown web have a mean diameter difference of at least 4.0 microns.

2. The nonwoven fabric laminate of claim 1, wherein the meltblown web comprises at least one layer of fine meltblown fibers.

3. The nonwoven fabric laminate of claim 2, wherein the fine meltblown fibers have an average diameter less than about 5.0 microns.

4. The nonwoven fabric laminate of claim 2, wherein the fine meltblown fibers have an average diameter of 0.1 micron to about 4.0 microns.

5. The nonwoven fabric laminate of claim 1, wherein the meltblown web comprises at least one layer of coarse meltblown fibers.

6. The nonwoven fabric laminate of claim 5, wherein the coarse meltblown fibers have an average diameter at least about 5.0 microns.

7. The nonwoven fabric laminate of claim 5, wherein the coarse meltblown fibers have an average diameter of about 6.0 microns to about 15 microns.

8. The nonwoven fabric laminate of claim 1, wherein the gradient fiber size structure comprises at least one layer of fine meltblown fibers bonded to at least one layer of coarse meltblown fibers.

9. The nonwoven fabric laminate of claim 8, wherein the meltblown web has an air permeability of about 176 cfm to about 227 cfm.

10. The nonwoven fabric laminate of claim 8, wherein the meltblown web has an opacity of about 39% to about 51%.

11. The nonwoven fabric laminate of claim 1, wherein the gradient fiber size structure comprises a layer of fine meltblown fibers positioned between a first layer of coarse meltblown fibers and a second layer of coarse meltblown fibers.

12. The nonwoven fabric laminate of claim 11, wherein the meltblown web has an air permeability of about 176 cfm to about 212 cfm.

13. The nonwoven fabric laminate of claim 11, wherein the meltblown web has an opacity of about 42% to about 51%.

14. The nonwoven fabric laminate of claim 1, wherein the meltblown web has a basis weight of about 5 gsm to about 34 gsm.

15. The nonwoven fabric laminate of claim 1, wherein the meltblown web has a basis weight of about 9 gsm to about 15 gsm.

16. The nonwoven fabric laminate of claim 1, wherein the first nonwoven layer and the second nonwoven layer each comprise a spunbond nonwoven layer.

17. A nonwoven fabric laminate, comprising:

a first spunbond layer;

a meltblown web having a first side bonded to a first side of the first spunbond layer, the meltblown web comprising at least one layer of coarse meltblown fibers having a first mean fiber diameter and at least one layer of fine meltblown fibers having a second mean fiber diameter wherein a difference between the first mean fiber diameter and the second mean fiber diameter is at least 4.0 microns;

a second spunbond layer having a first side bonded to a second side of the meltblown web.

18. The nonwoven fabric laminate of claim 17, wherein the meltblown web further comprises a third layer of meltblown fibers.

19. A nonwoven fabric laminate, comprising:

a meltblown web having at least one layer of coarse meltblown fibers and at least one layer of fine meltblown fibers, the coarse meltblown fibers having an average diameter of at least about 5 microns and the fine meltblown fibers having an average diameter of less than about 5 microns,

the at least one layer of coarse meltblown fibers and the at least one layer of fine meltblown fibers provide a gradient fiber size structure.

20. The nonwoven fabric laminate of claim 19, wherein the layer of course meltblown fibers has a mean fiber diameter at least 4.0 microns greater than a mean fiber diameter of the layer of fine meltblown fibers.

21. A medical gown comprising the laminate of Claim 19.

22. A medical drape comprising the laminate of Claim 19.

23. A garment comprising the laminate of Claim 19.

24. A sterilization wrap comprising the laminate of Claim 19.

25. A towel comprising the laminate of Claim 19.

26. A foot cover comprising the laminate of Claim 19.

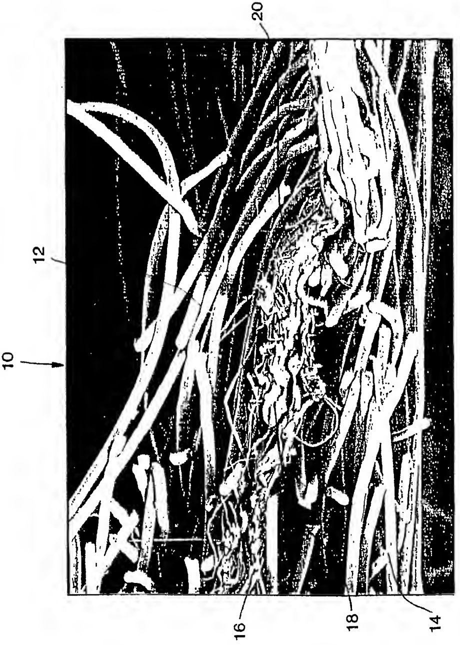

FIG. 1

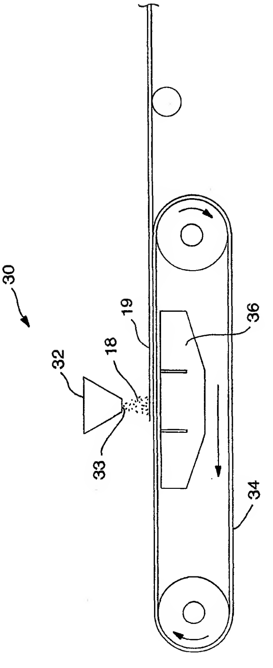

FIG. 2

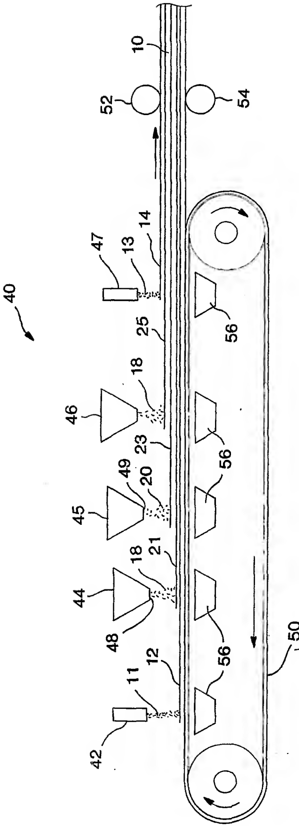
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FIG. 3